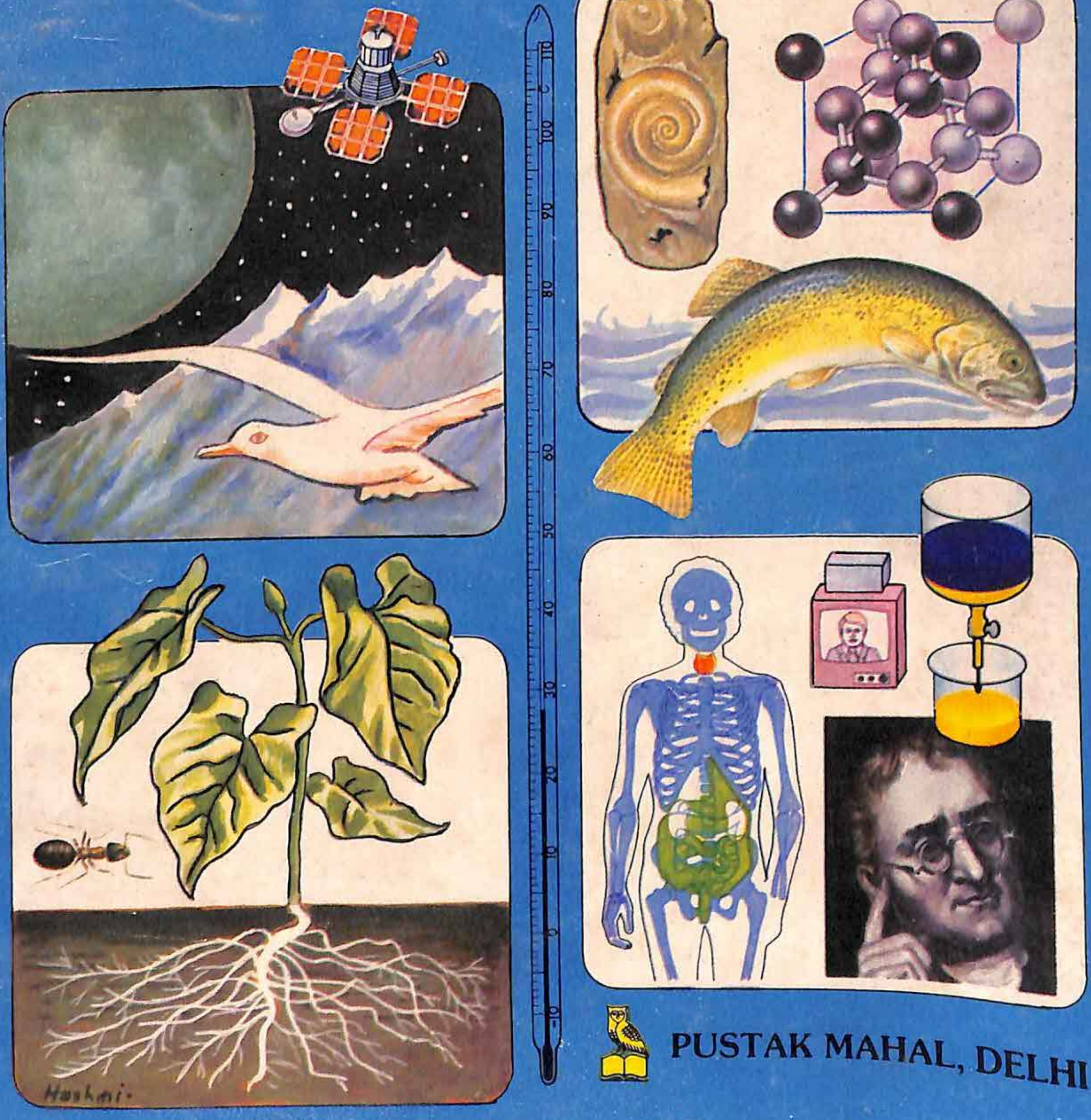
WINDRIDGE

GENERAL SCIENCE

ONE



PUSTAK MAHAL, DELHI

General Science

BOOK ONE

General Science

BOOK ONE

by Charles Windridge

edited by Patrick J. Kenway, B.Sc.

illustrated by Barry Davies

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PUSTAK MAHAL, DELHI

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Author's Note

REVISED EDITION

This book is a completely up-dated and fully revised edition of General Science, Book One, which was first published in 1958.

The complete revision of this book and the other books in the series ensures that they are fresh in their approach and that the series as a whole will satisfy the needs of pupils in this day and age—the Space Age. The revision has been carried out with a proper regard for the latest developments in scientific research and thought, the recent trends in the methodology of science teaching, and the ever-changing pattern of technological advancement, and in the awareness that science is not just a body of knowledge but also a set of methods and a way of thinking. Much of the revision has been concerned with those modifications that have been made necessary by the omission of obsolescent material, the introduction of S I metric units, new discoveries, changes in examination requirements, etc.; but the series still retains those familiar characteristics which, as very many reprints over the years clearly indicate, have made it very popular and established it as being thoroughly reliable and adequate.

This series provides a course in general and combined science that is complete, but in no way overloaded, for pupils of average ability within the 11 to 16 age-range. It is essentially a study of natural science—physics, chemistry, biology, astronomy, geology, meteorology, etc.—and its applications in technology and other fields. The fifth book in this series caters for those pupils who are taking preliminary technical courses or examinations in general science of the standard of the Certificate of Secondary Education, and it provides a sound groundwork for the important minority who will take trade courses and advanced courses in technology later on.

The course is presented as an integrated and solid core of indispensable and basic facts and techniques combined with coherent topics that will promote purposeful activities, encourage individual research and satisfy modern examination requirements. There are opportunities for pupils to acquire and use knowledge and skills in both real and realistic situations. They are made to understand that the ability to handle scientific situations, rather than the mere mental storage of scientific facts, is the proper end-product of scientific education.

An important feature of the books in this series is that both the diagrams and the text are almost entirely self-explanatory, and this, coupled with the tremendous variety and the wide coverage in the contents, means that most pupils could work from them without very much assistance from the teacher. Therefore, in addition to their usefulness as textbooks of the traditional type, the books are very suitable for use with mixed ability classes and for homework, projects and individual study.

The practical work is straightforward and homely, so that, quite often, it can be performed with simple or improvised apparatus. The diagrams are examples on which pupils can base their own drawings. The exercises, given at the end of the books, are intended to supplement the pupils' practical work and records of experiments by providing extra practice in written work, drawing, the use of scientific terms, calculations, etc., and, of course, they are useful for revision purposes. The units of measurement are S I (Le Systeme International d' Unités) and decimal notation is used almost exclusively throughout.

Full consideration has been given to the various reports and recommendations of such bodies as the Certificate of Secondary Education and University Examination Boards, the Association for Science Education, the Council of Technical Examining Bodies, the Royal Society, the Royal Institute of Chemistry, etc.

C.W.

Metric Units

THE STANDARD INTERNATIONAL SYSTEM OF UNITS

Le Systeme International d' Unités, which is known here as the Standard International System of Units, or, more simply, as S I, is the official measuring system of the United Kingdom, and all the units of measurement that are used in this series of books are part of this system except in a few instances where, for historical or some other special reasons, it is necessary to do otherwise.

Some of the S I fundamental, derived and supplementary units are:

physical quantity	*unit*	*symbol*
length	metre	m
mass	kilogram	kg
time	second	s
temperature	kelvin	K
temperature	degree Celsius (customary unit)	°C
electric current	ampere	A
luminous intensity	candela	cd
area	square metre	m^2
volume	cubic metre	m^3
velocity	metre per second	m/s
acceleration	metre per second per second	m/s^2
force	newton	N
heat, work and energy	joule	J
power	watt	W

The above-mentioned units and some others not already mentioned are defined and fully explained at appropriate places in the text.

As far as is possible all fractions are expressed in decimal notation so that full benefit is derived from a system of units whose multiples and sub-multiples can be so easily expressed in that same notation.

Further information about S I units and conventions can be obtained from the publications that are issued from time to time by such bodies as the Royal Society, the Association for Science Education, the British Standards Institution, the Royal Institute of Chemistry, Her Majesty's Stationery Office, the Council of Technical Examining Bodies, the Department of Education and Science, etc. The booklets *The Use of S I Units in the Early and Middle Years of Schooling* and *S I Units, Signs, Symbols and Abbreviations for Use in School Science*, both published by the Association for Science Education, are particularly helpful publications.

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1 Science

Science and you

Do you realize just how much you depend upon science for your health, comfort and entertainment?

Anaesthetics, refrigerators, detergents, piped water, railways, jet aircraft, motor vehicles, telephones, radios, colour televisions, tape recorders, vacuum cleaners, newspapers, computers, explosives and weather forecasts are but a few of the things which would not have been available to you if you had lived a few centuries ago. How fortunate you are to be living in the present century!

How science began

Science began with curiosity. Primitive man, like the children of today, must have thought about the causes of thunder and lightning; he must have wondered about the Sun, the fiery sky-god that gave him warmth and light.

Simple tools, such as the axe—a stone tied to a stick—and simple machines, such as the wheel—a log roller for trundling heavy loads—must have been regarded as marvellous labour-saving devices by their inventors, who lived thousands of years ago.

It is probable that the first boats used by men were logs. You can well imagine how some primitive man might have observed a tree trunk floating in water. Perhaps he cut down a tree, experimented with it, and then discovered that the floating log would carry him along. He would notice that a large log would carry his weight and that a small log would not. He would discover that the success of his experiment depended upon the size of the log. In fact, he would have made a simple measurement.

The three methods of science

The primitive man *observed, experimented* and *measured.* The modern scientist uses the same three methods, but, of course, the observations, experiments and measurements are often complicated. He observes nature to see how she works. He experiments by copying nature in his laboratory. He makes very careful measurements.

In this science course you will be able to *observe, experiment* and *measure,* and so discover facts for yourself just as the scientist does.

The branches of science

Science has many branches, and each of them is a science. The science of *biology,* for example, deals with living things—plants and animals. The science of *mathematics* is concerned with sizes in number, weight, time, space, etc.

Here are a few of the branches of science: *Physics*—heat, light, sound, electricity, magnetism, etc. *Chemistry*—what materials are made of. *Geology*—rocks and minerals. *Geography*—the Earth's physical features, climate, population and products. *Mechanics*—machines and buildings. *Astronomy*—the Sun, Moon and stars. *Psychology*—the human mind and behaviour. *Meteorology*—weather-forecasting. *Botany*—plants. *Zoology*—animals.

By the way, *biology* is really two sciences in one—*zoology* and *botany.*

Natural science and technology

The word *science* means "knowledge", but it is usually accepted to mean "knowledge of nature". However, to be strictly accurate, what we call *science* should be called *the science of nature* or *natural science.*

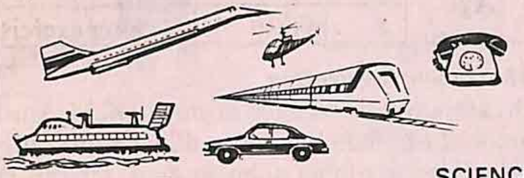
We apply our knowledge of nature in such activities as farming, industry, space travel, etc. The knowledge and skill involved in these activities are called *technology.* Engineers, architects, printers and meteorologists are *technologists.*

SCIENCE AND YOU

Comfort

Health

Entertainment

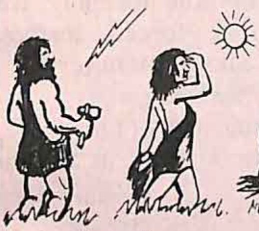


Travel

SCIENCE MEANS HEALTH, COMFORT AND LABOUR-SAVING

Work

HOW SCIENCE BEGAN



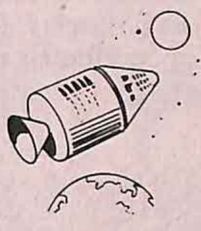
Curiosity

Comfort

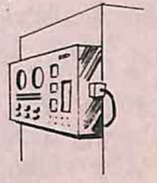
Labour-saving

HOW THE SCIENTIST WORKS

Observation



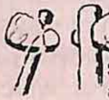
Experiment



Measurement

THE FIRST TECHNOLOGISTS

The first technologists were the early men who invented —



Stone axes

the first tools

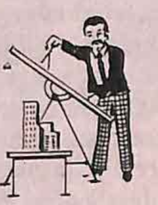
the first boat

Rollers were used in building the Pyramids in Egypt

the first wheel

MODERN TECHNOLOGISTS

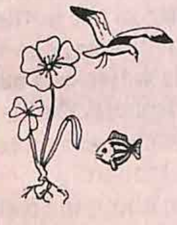
Television engineer



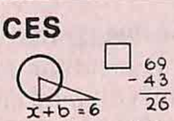
Architect

Motor mechanic

SOME SCIENCES

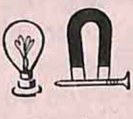


Biology



Mathematics

Chemistry



Physics

Geology

Geography

Astronomy

Meteorology

Mechanics

Psychology

2 The Atmosphere

Air is real

Air cannot be seen, yet we believe that it exists. We have only to watch a flag fluttering in a breeze, leaves tossing and turning in a wind, or smoke blowing from a chimney, and we know that air is very real. The damage done to buildings by a severe gale is an unpleasant proof that air has a real existence. Air can be felt when we cycle quickly or stand in front of a fan.

The atmosphere

The ball-shaped Earth on which we live is surrounded by a layer of air over 300 kilometres in depth; it is called the *atmosphere.*

The illustration shows the heights which have been reached by birds, balloons and aeroplanes. Of course, artificial satellites and spacecraft reach tremendous heights and then enter into space; they leave the Earth's atmosphere entirely.

Air for life

Living things, both plant and animal, need air. Miners entombed by a fall of rock soon die when all the available air has been made foul by their breathing.

Pure air is necessary for health. That is why doctors advise us to breathe deeply and to sleep with our bedroom windows open. We know from experience that breathing foul air makes us feel drowsy.

An athlete running in a race requires more air than a person at rest and he breathes much faster. Some animals breathe faster than others. This is because some animals need more air than others. A bird resting on a perch breathes faster than a man who is walking or running. Persons climbing a high mountain must breathe more quickly to obtain sufficient air. There is less air at great heights. Large modern aircraft fly at great heights and enter the *stratosphere,* where there is little air, but they have sealed and *pressurized* cabins to ensure that the crew and the passengers are comfortable and have an adequate supply of air. Normally, at rest, we breathe in and out about 16 times per minute.

Measuring breathing rates

Use a watch to measure your breathing rate and those of persons of different ages at rest and after exercise. Make a chart. What does the chart tell you?

BREATHING RATES		
Age	Breaths per minute	
	at rest	after exercise

Measuring inspiration

Breathing in air is called *inspiration*. Measure the amount of air in one normal inspiration of your own. Use a rubber tube to suck air out of an inverted bottle standing in water. Empty the water drawn into the bottle into a litre measure. You now know the amount of air, in litres, which you take in when you breathe normally. Repeat this experiment with a forced inspiration. Calculate the litres of air per minute you need when you are breathing normally.

Note: 1000 litres = 1 cubic metre (1 m^3).

Litres of air per minute = water in measure × normal breathing rate

Measuring expiration

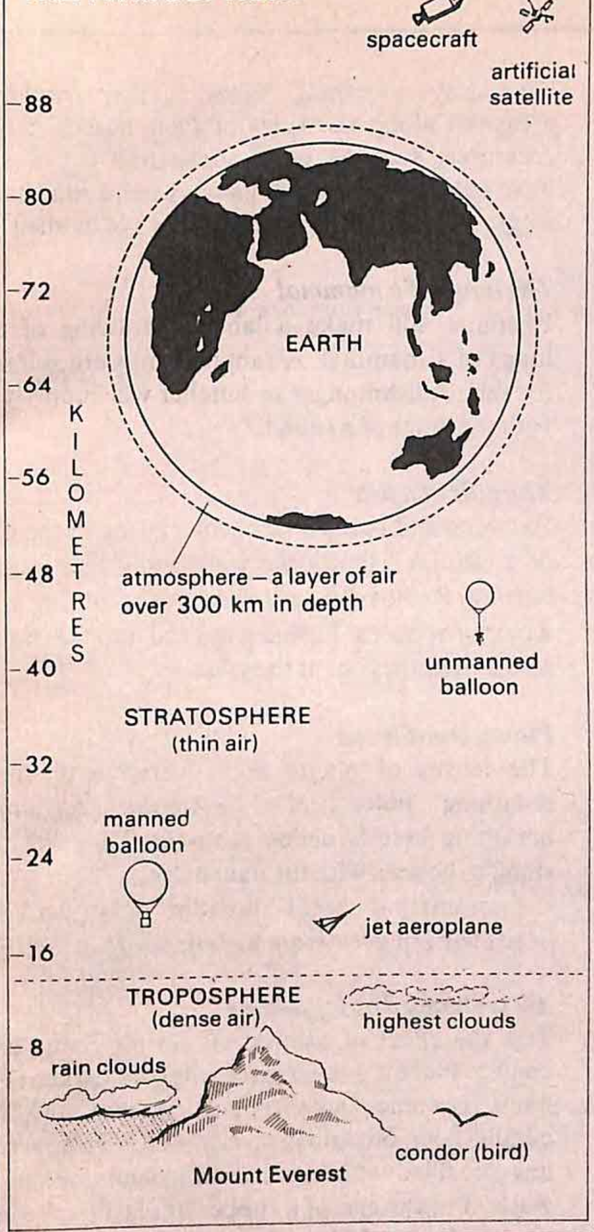
Breathing out is called *expiration*. Measure the amount of air in one normal expiration of your own. Blow through a rubber tube into an inverted bottle, full of water, which is standing in a trough containing water. Use a litre measure to determine the amount of water now contained in the bottle. Subtracting this amount of water from the amount of water which the bottle holds when full gives the amount of air, in litres, which you have breathed out. Repeat this experiment with a forced expiration.

The force of the atmosphere

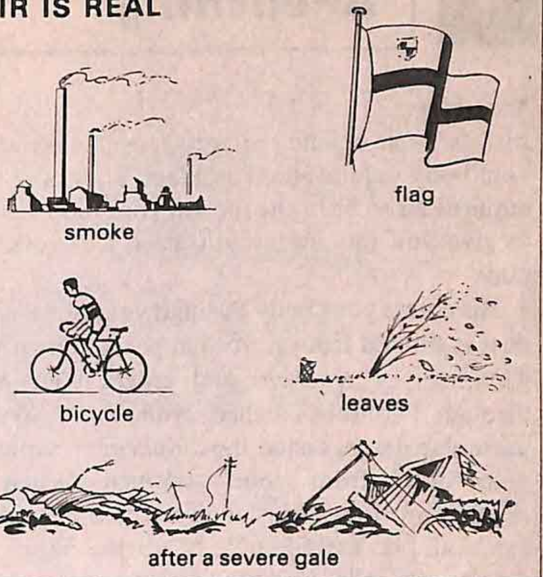
In the last experiment the water in the bottle did not run out until you were able to replace some of it with air from your lungs. The water was held in place by the force of the atmosphere, that is, the weight of the air in the atmosphere pressing downwards on the water in the trough.

In a later book you will learn about the force of the atmosphere and the mass and weight of air.

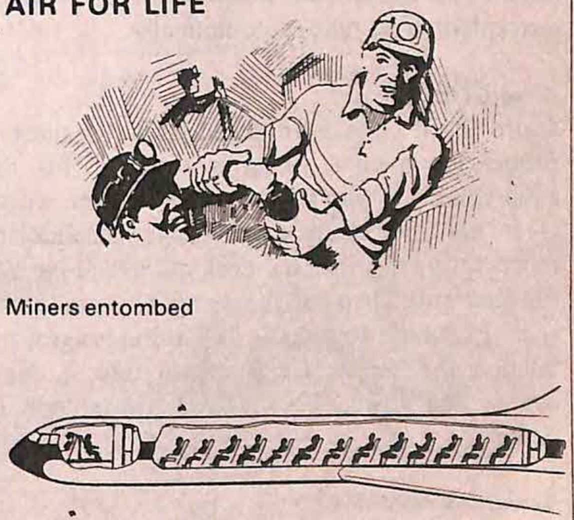
THE ATMOSPHERE



AIR IS REAL



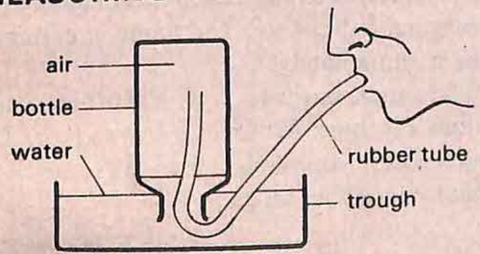
AIR FOR LIFE


Miners entombed

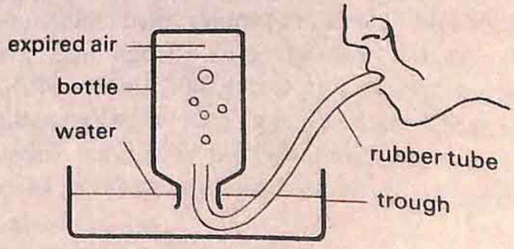
Air in aircraft

No air means death

MEASURING INSPIRATION



MEASURING EXPIRATION



3 Breathing

Breathing

Just as a car engine requires petrol as a fuel, so your body requires food as a fuel. Your body also requires air to burn the food in your bloodstream to give you the energy you need for work and play.

Air enters your body through your nose, where dust is filtered from it. It then passes down your windpipe, or *trachea,* and enters your *lungs* through two tubes called *bronchi.* A layer of muscular tissue, called the *diaphragm,* separates your chest from your *abdomen.* When the diaphragm rises, your lungs are compressed and used air is forced out of them. When the diaphragm falls, your lungs expand and air is drawn into them. This upwards and downwards movement takes place automatically.

A model lung

Close off the open end of a bell-jar with a sheet of rubber to which a string is attached. Fix the rubber in place with wire. Insert a stopper, with a glass tube to represent a trachea, and a balloon to represent a lung, into the neck of the bell-jar (see the diagram). Then pull the string. This causes the sheet of rubber to behave like a diaphragm; the balloon *inflates* as air is drawn into it. Now release the string. This allows the balloon to *deflate.*

Breathing organs

Animals need air in order to live, but all animals do not breathe in the same way. *Mammals,* which are a group of warm-blooded animals that includes dogs, rabbits and ourselves, breathe through lungs. Reptiles breathe through lungs. Snakes and lizards are reptiles. Birds have lungs. Fish breathe through *gills.* Frogs and toads breathe through lungs, but the tadpoles of frogs and toads breathe through gills in the early stages of their lives. Some simple creatures, such as earthworms, breathe through their skins. Insects have tiny breathing tubes, called *tracheae,* arranged along the sides of their bodies. Some creatures, such as pond snails and octopuses, have special breathing organs. A pond snail has a single breathing hole under the edge of its shell.

The lungs of a mammal

Examine and make a labelled drawing of the lungs of a mammal. A rabbit's lungs are suitable for this. A fishmonger or butcher will supply you with the lungs of a rabbit.

The gills of a fish

Examine and make a labelled drawing of the gills of a fish. A fishmonger will supply you with a herring. Remove the *gill-cover* of the herring with a pair of scissors. Push a glass rod into the mouth so that it comes out at the gills.

Plants breathe too

The leaves of plants are covered with small breathing holes called *stomata.* A single breathing hole is called a *stoma.* They are too small to be seen with the naked eye.

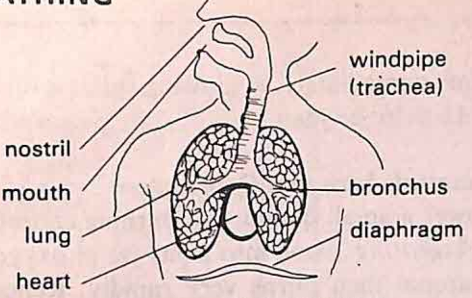
Germinating seeds breathe very actively. Seeds will not *germinate* without air.

Air is changed by breathing

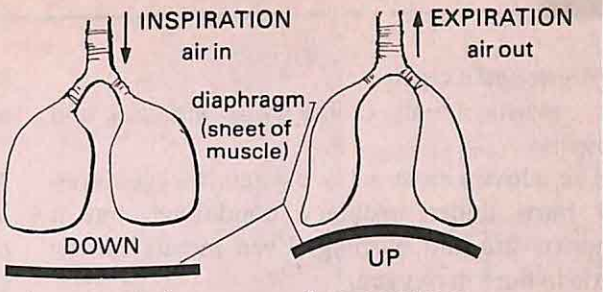
Test the effect of expired air on the flame of a candle. Place a gas-jar over a lighted candle. The flame becomes smaller and smaller and the candle goes out after several seconds. Invert a gas-jar, filled with water, in a trough containing water. Put the end of a rubber or plastic tube into the gas-jar, and blow through the tube until the gas-jar is full of expired air. Then place the gas-jar over a lighted candle. The flame is extinguished almost immediately.

The candle burns for a time in ordinary air, but it does not burn for long in expired air. The air which enters your lungs is not the same as the air which leaves your lungs.

BREATHING



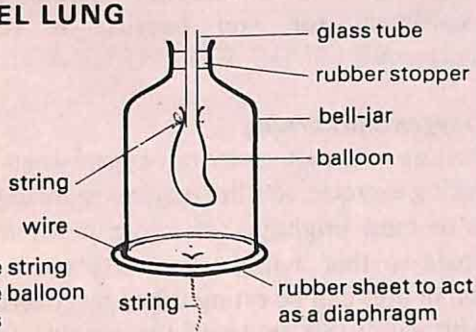
Human respiratory system



Lungs expand

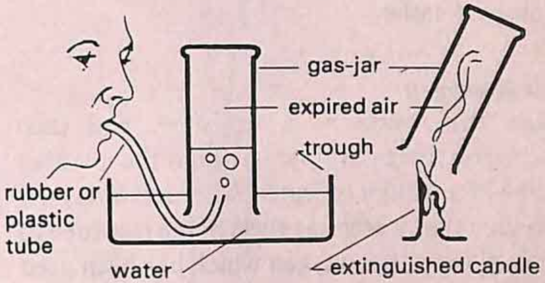
Lungs contract

MODEL LUNG

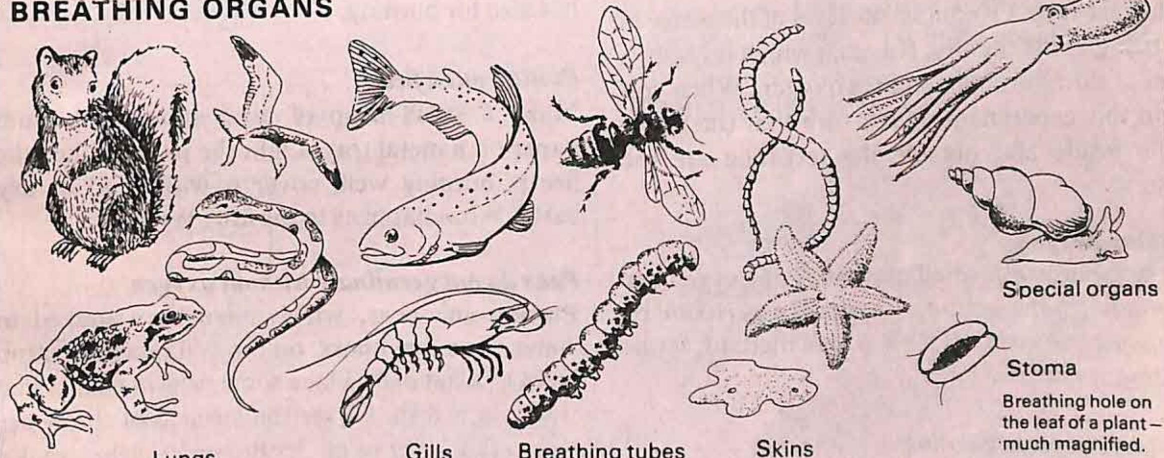


Pull the string and the balloon inflates

AIR IS CHANGED BY BREATHING



BREATHING ORGANS


Breathing hole on the leaf of a plant – much magnified.

Lungs

Gills

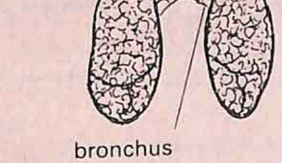
Breathing tubes

Skins

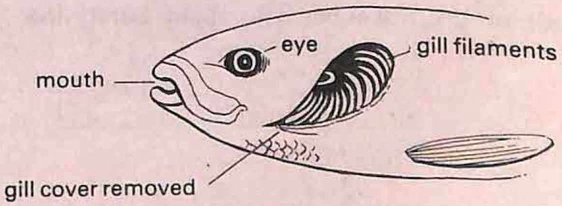
Special organs

Stoma

LUNGS OF A RABBIT



GILLS OF A HERRING



4 Oxygen

Nitrogen and oxygen

Air consists mainly of the gases *nitrogen* and *oxygen*.

The active gas in air is oxygen. Oxygen does not burn under ordinary conditions, but it supports life and burning. Even metals can be made to burn in oxygen.

Nitrogen is not very active. Things do not burn in nitrogen. However, if air consisted of oxygen only, it would be too "rich" for plants and animals to breathe.

1/5 air is oxygen

Moisten the inside of a test-tube, and then sprinkle iron filings around it. Stand the inverted test-tube in a trough of water. After a few days, it will be seen that water has risen in the test-tube to take the place of the oxygen which has been used up in the rusting of the iron. The height of the water in the test-tube is roughly 1/5 of the height of the test-tube. Of course, the level of the water in the trough falls slightly. Rusting, which is really a form of slow burning, requires oxygen. When you begin this experiment, make sure that the water levels inside and outside the test-tube are the same.

Making oxygen

In the laboratory, small quantities of oxygen can be made by the action of *hydrogen peroxide* on *manganese dioxide*. This is a safe method, for no heating is necessary.

Oxygen supports burning

Put a small quantity of manganese dioxide at the bottom of a test-tube. Add a little hydrogen peroxide solution. Put a glowing splint into the mouth of the test-tube. The splint bursts into flame immediately. A glowing splint is often used as a test for oxygen.

Materials burn rapidly in oxygen

Lower a small quantity of burning *charcoal* in a *deflagrating spoon* into a gas-jar of oxygen. The charcoal then burns very rapidly. Repeat with burning *sulphur*, bread, iron filings and *magnesium*. Your teacher should do this experiment for you because it could be dangerous.

Oxygen and burning

Just as you require more oxygen when you are taking exercise, so a fire requires more oxygen if it is to burn brightly. You use a poker to loosen coals so that a fire will receive more oxygen. Small fires can be extinguished by covering them with sand; this shuts off the supply of oxygen. Oxygen, then, is necessary not only for breathing but also for burning.

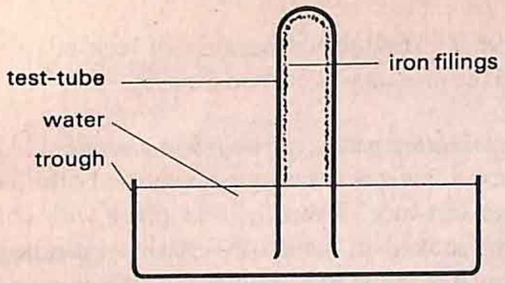
Putting out a fire

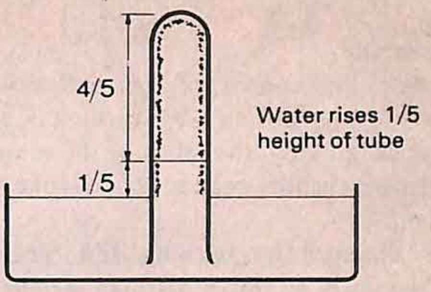
Make a small heap of used match-sticks and paper on a metal tray. Light the paper. When the fire is burning well, cover it with sand or dry earth. What happens to the fire? Why?

Peas do not germinate without oxygen

Place some peas, which have been soaked in water for a few hours, on moist flannel or cotton wool in a flat dish. Place some peas in cold boiled water in a dish. Cover the surface of the water with a thin layer of oil. Examine the dishes after a few days. The peas on the damp flannel have germinated, but the others have not. What is the purpose of the layer of oil? Why is boiled water used?

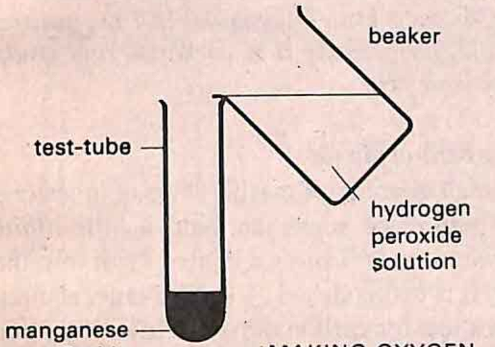
1/5 AIR IS OXYGEN



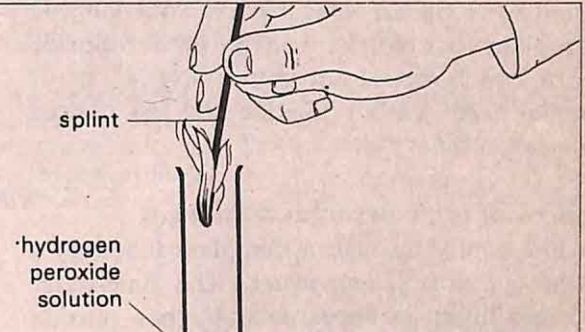


After a few days

OXYGEN SUPPORTS BURNING

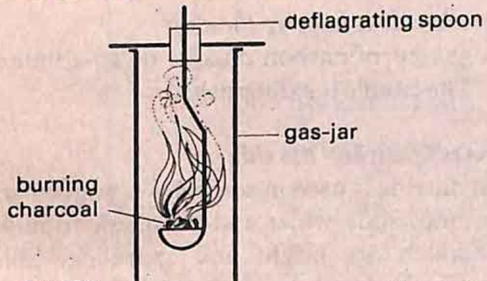


MAKING OXYGEN



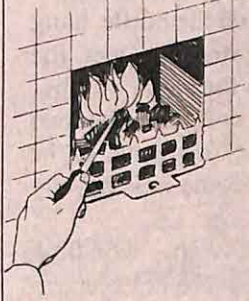
THE OXYGEN CAUSES THE GLOWING SPLINT TO BURST INTO FLAME

RAPID BURNING IN OXYGEN

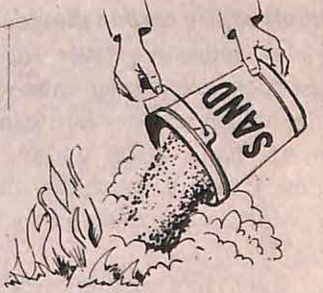


Repeat with iron filings, bread, magnesium ribbon and sulphur

BURNING NEEDS AIR

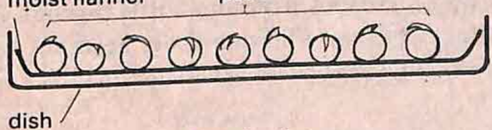


Poking a fire

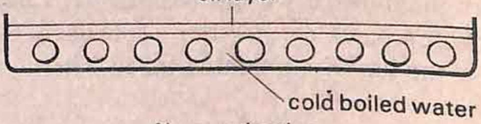


Extinguishing a small fire with sand

PEAS REQUIRE OXYGEN FOR GERMINATION



Germination



No germination

5 Carbon Dioxide

Carbon dioxide

A small part of air consists of *carbon dioxide* gas. This gas is formed during the breathing of plants and animals and by the burning of materials which contain carbon, such as wood, coke, coal, wax and oil.

Air is changed by burning and breathing. Oxygen is used up by a burning candle and carbon dioxide gas is formed. The oxygen contained in the air which enters your lungs is changed in your bloodstream into carbon dioxide gas. A candle would not burn in expired air. It contains more carbon dioxide and less oxygen than does ordinary air.

Expired air contains carbon dioxide gas

Breathe gently through a thin glass tube into a bottle containing *lime-water*. The lime-water becomes milky in appearance. Carbon dioxide gas always has this effect on lime-water. If lime-water is allowed to stand in ordinary air, it eventually becomes milky because ordinary air contains some carbon dioxide.

Animals expire carbon dioxide

Put a few snails in a bottle. Inside the bottle, hang a test-tube containing lime-water. Stopper the bottle. Set up another bottle in the same way but without snails. After a day, compare the two bottles. You will notice that the lime-water in the bottle containing snails has become milky. Why is this?

Repeat this experiment with woodlice, earthworms, a mouse and a frog. Do not keep the mouse and the frog in the bottle too long or they will die.

Plants expire carbon dioxide

Put a pot-plant inside a stoppered bell-jar. Cover the jar with a black cloth. After a few days, test the air in the jar with a lighted taper. The taper flame is extinguished because of lack of oxygen and the presence of carbon dioxide.

Germinating peas expire carbon dioxide

Place a few germinating peas at the bottom of a large test-tube. Keep them in place with cotton wool soaked in water. Invert the test-tube and allow it to stand in a glass dish containing *caustic soda* solution. After a few days, the caustic soda solution will have risen inside the test-tube. What has happened? Caustic soda solution *absorbs* carbon dioxide gas. *Take care with the caustic soda solution because it is corrosive and could damage your skin.*

Making carbon dioxide

Put a small quantity of marble chips or limestone at the bottom of a gas-jar. Add a little *dilute hydrochloric acid.* Lower a lighted taper into the gas-jar. It is extinguished. A lighted taper is often used as a test for carbon dioxide. However, some gases are flammable; therefore, this test could be dangerous and should only be used with caution.

Carbon dioxide is heavier than air

Pour a gas-jar of carbon dioxide on to a lighted candle. The candle is extinguished.

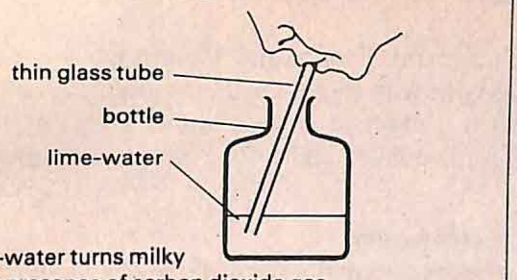
Some uses of carbon dioxide

Carbon dioxide is used in some fire extinguishers. It is put into soda water and lemonade to make drinks which are bright and sparkling. Solid carbon dioxide, or "dry ice", as it is called, is occasionally used for keeping ice-cream cold.

Carbon dioxide in fizzy drinks

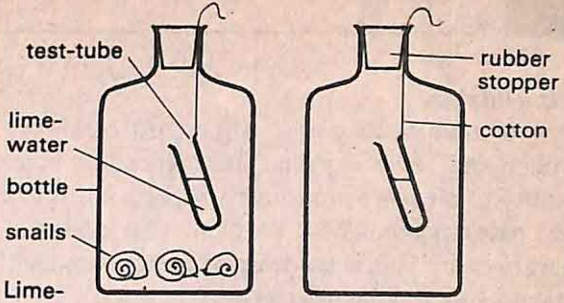
Insert a glass tube and a rubber stopper into the neck of a bottle containing lemonade. Bubble the gas which escapes from the bottle through lime-water in a beaker. The lime-water becomes milky, showing that the gas is carbon dioxide.

EXPIRED AIR CONTAINS CARBON DIOXIDE



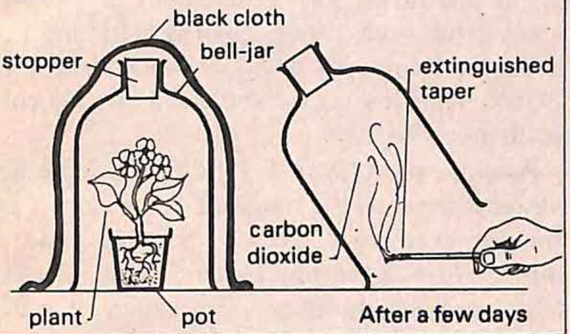
Lime-water turns milky in the presence of carbon dioxide gas

ANIMALS EXPIRE CARBON DIOXIDE



Lime-water becomes milky Lime-water remains clear

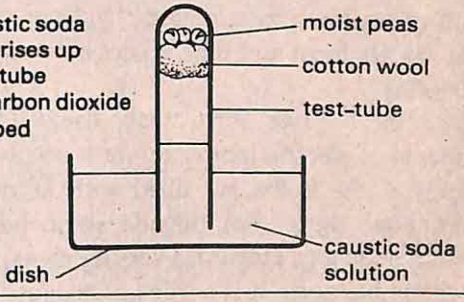
PLANTS EXPIRE CARBON DIOXIDE



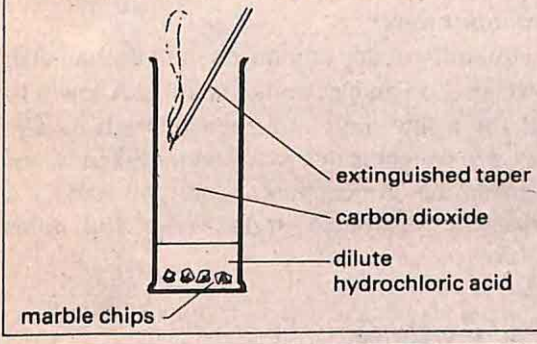
After a few days

GERMINATING PEAS EXPIRE CARBON DIOXIDE

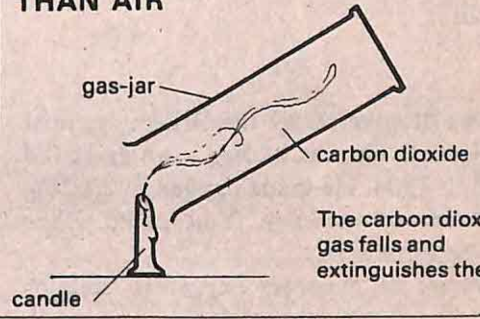
The caustic soda solution rises up the test-tube as the carbon dioxide is absorbed



MAKING CARBON DIOXIDE

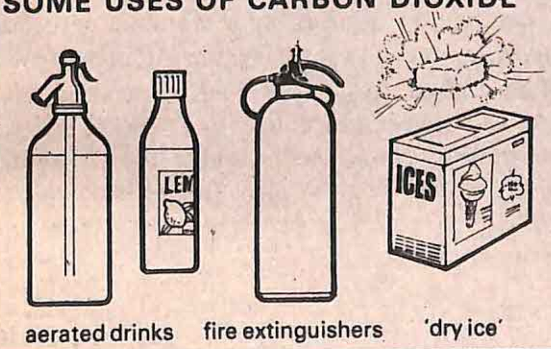


CARBON DIOXIDE IS HEAVIER THAN AIR

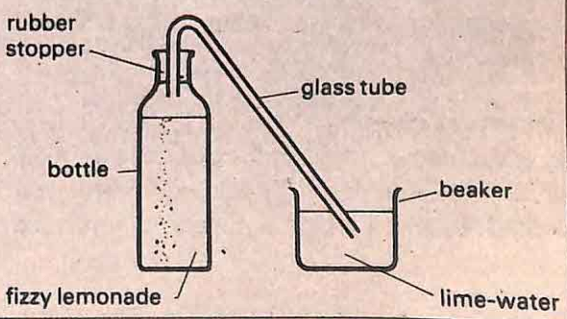


The carbon dioxide gas falls and extinguishes the candie

SOME USES OF CARBON DIOXIDE



CARBON DIOXIDE IN FIZZY DRINKS



6 Air

Air is a mixture

Air is a mixture of gases. About 4/5 of air is nitrogen and 1/5 is oxygen. This means that in a quantity of air there are roughly 4 parts nitrogen and 1 part oxygen. About 1% of air, that is, about 1 part in every 100, is made up of carbon dioxide, *water vapour* and the *inert* gases.

The inert gases

The inert gases, which are *argon, neon, xenon, krypton* and *helium,* are present in air in very small quantities. *Inert* means "without action". They do not burn and they do not act upon other chemicals.

The inert gases have their uses. The hot filaments of electric lamps do not burn away too quickly if the bulbs are filled with argon. The illuminated signs seen outside some buildings contain neon gas. Helium, a very light gas, is used for filling balloons. It is a safe gas because it does not burn. *Hydrogen,* another gas used for filling balloons, is dangerous because, if ignited, it burns rapidly in air.

Oxygen

Oxygen was discovered by the British scientist Joseph Priestley. He was a clergyman and lived from 1733 to 1804. He made oxygen by heating the *red oxide of mercury*. You could make oxygen in the same way.

For commercial purposes oxygen is made by turning ordinary air into a liquid. The air is compressed and cooled and then allowed to evaporate. The nitrogen part of the air becomes a gas, leaving liquid oxygen behind. This is stored in cylinders.

Some uses of oxygen

Oxygen is used in hospitals for patients who have difficulty in breathing. The Everest climber Sir Edmund Hillary carried a special oxygen set. Space travellers to the Moon take a supply of oxygen with them, for there is no oxygen on the Moon. Oxygen is used in oxy-acetylene flames for the welding and cutting of iron and steel.

Water vapour

Water exists in the atmosphere as a *vapour.*

Sudden cooling causes water vapour to turn into tiny drops of water which appear to us as clouds and mists. The white clouds of "steam" which issue from the spout of a kettle are not steam but many tiny drops of water formed by the hot steam leaving the kettle and meeting cold air. Steam is invisible.

A housewife prefers a dry day for doing her washing, for then the moisture in the clothes on the line evaporates quickly to become water vapour. In a damp atmosphere, which already contains much moisture, evaporation of water from the damp clothes takes place very slowly.

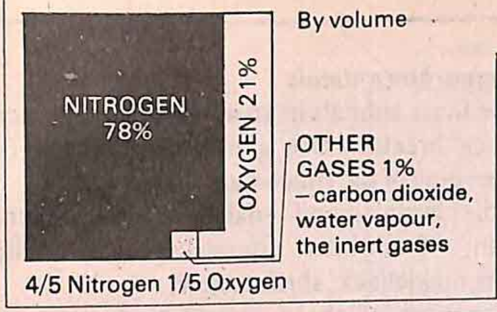
Air contains water

Put a quantity of dry common salt in a small dish and weigh it on an electronic balance. Allow it to stand for a few days and then reweigh it. The increase in weight is due to the water taken by the salt from the atmosphere. Common salt is a *hygroscopic* substance. It takes up and holds moisture.

A weather indicator

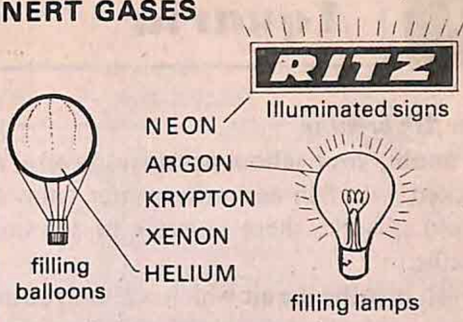
Soak a small piece of white blotting paper, about 2 centimetres square, in a solution of *cobalt chloride*, and allow it to dry. Paste it on to a piece of cardboard. Attach a suitable illustration, such as a coloured picture cut out of a magazine, to the cardboard. Hang the indicator in a sheltered place where it can be seen. During dry weather the cobalt chloride paper is blue; during wet weather, it is pink.

AIR IS A MIXTURE

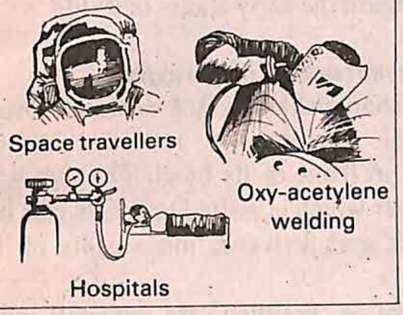


Joseph Priestley
1733-1804
Discoverer of oxygen

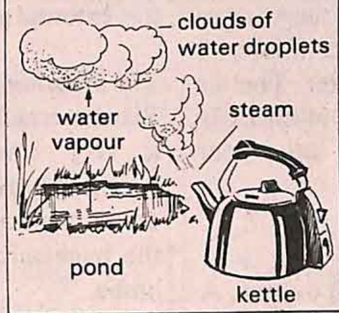
THE INERT GASES



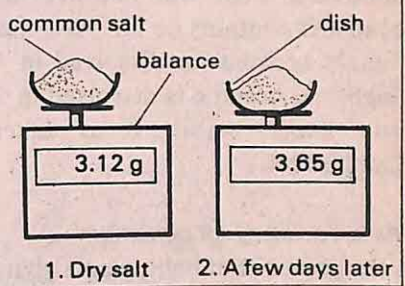
SOME USES OF OXYGEN



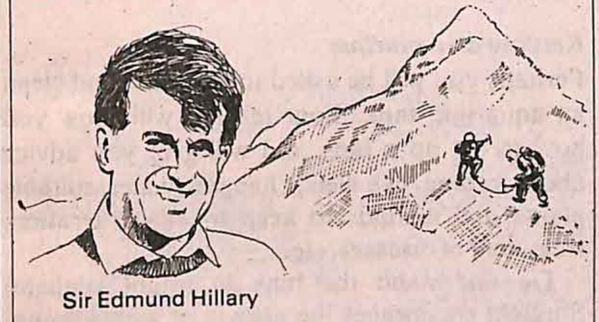
WATER VAPOUR



AIR CONTAINS WATER

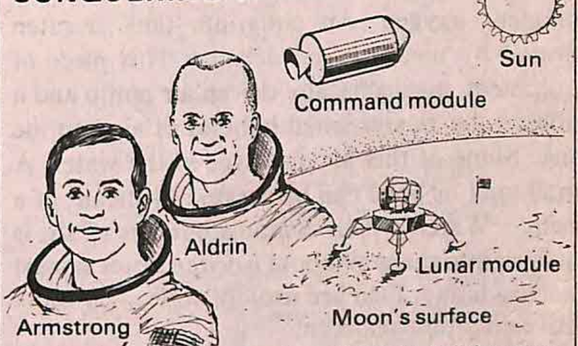


CONQUERING EVEREST



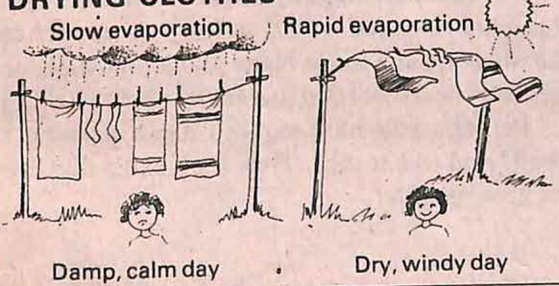
Sir Edmund Hillary, the New Zealand explorer and mountaineer, and Sherpa Tenzing Norkhay, were the first men to climb Mount Everest. They reached the summit on 29th May, 1953. They used oxygen apparatus to help them in breathing.

CONQUERING SPACE

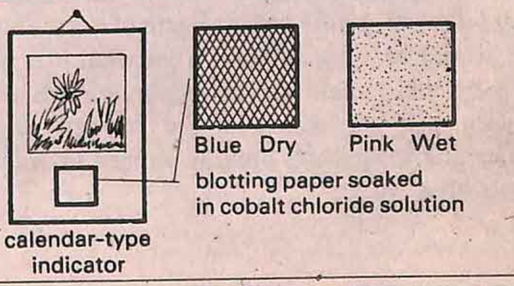


On 21st July, 1969, two American astronauts, Neil Armstrong and Edwin Aldrin, landed on the Moon. They were the first men to walk on its surface. They took a supply of oxygen with them, for there is no air on the Moon.

DRYING CLOTHES



WEATHER INDICATOR



7 Aquaria

How fish breathe

No doubt, your school possesses several aquaria stocked with fish and other water animals. You should observe these animals to see how they breathe.

Fish breathe the air which is dissolved in water. Water containing dissolved air enters the mouth of a fish, passes over its gills giving up the oxygen which the fish needs, and leaves from behind the gill-covers. Fish will not live in boiled water because it contains no air. As a matter of fact, all animals breathe air dissolved in water. The air which you breathe is dissolved in the moisture in your lungs before it is taken into your bloodstream.

The aeration of an aquarium

In the presence of light, plants give out oxygen. A properly kept aquarium tank should, therefore, contain water plants so that the fish in it will have sufficient oxygen. An aquarium tank is often aerated by means of an *aerator*. This piece of equipment, an electrically-driven air pump and a rubber tube, passes small bubbles of air into the tank. Some of this air dissolves in the water. A small tank or bowl can be aerated by means of a syringe. Water, which contains bubbles of air, is squirted into the tank about a dozen times at least once each day. Fish are usually noticeably more active after this treatment.

The balance of nature

The plants and animals in an aquarium tank are a good example of the balance of nature. The animals use the oxygen made by the plants. If there were no plants on this Earth of ours, animal life would be very different from what it is now. Indeed, there might not be any animal life at all. Plants help to maintain the oxygen in the atmosphere. Animals breathe oxygen in order to keep alive.

Some aquarium animals

Observe these animals in an aquarium and notice how they breathe. Use a magnifying glass to examine some of the smaller animals.

Caddis larva; pond snail; tadpole; water-boatman; freshwater mussel; horse-leech; goldfish; stickleback; shrimp; newt.

Note: some of these animals will only be available at certain times of the year. The tadpole has external gills in the early stages of its life.

The breathing movements of a crayfish

Place a crayfish in a shallow tank of water. Drop a very small quantity of red dye about 3 centimetres in front of its head. The dye will colour the water which is wafted under its gills by the backwards and forwards movements of its limbs.

The gills of a crayfish are covered and protected by a hard shell called a *carapace*.

Keeping an aquarium

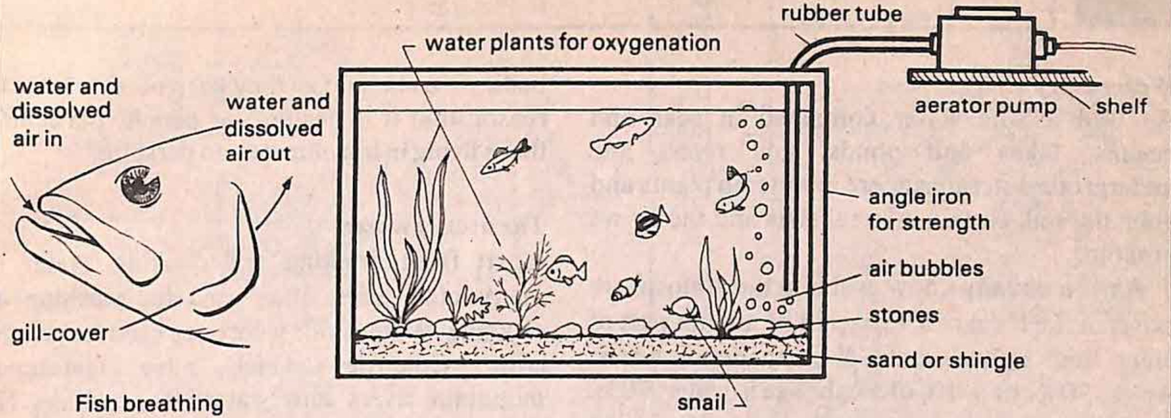
Perhaps you will be asked to maintain and clean an aquarium tank. Your teacher will show you how to set up a tank and will give you advice about feeding, live diets, changing water, suitable plants and animals to keep together, aeration, treatment of diseases, etc.

Do not stand the tank in bright sunlight. Sunlight encourages the growth of a green scum of *algae,* which are tiny water plants, on the bottom and sides of the tank. Keep a few snails in the tank. These help to keep the water clean; they feed on algae.

Rubbish and algae attached to the sides of the tank are removed with a scraper. A scraper can be made from a razor blade and a thin stick, or a piece of steel wool tied to a stick.

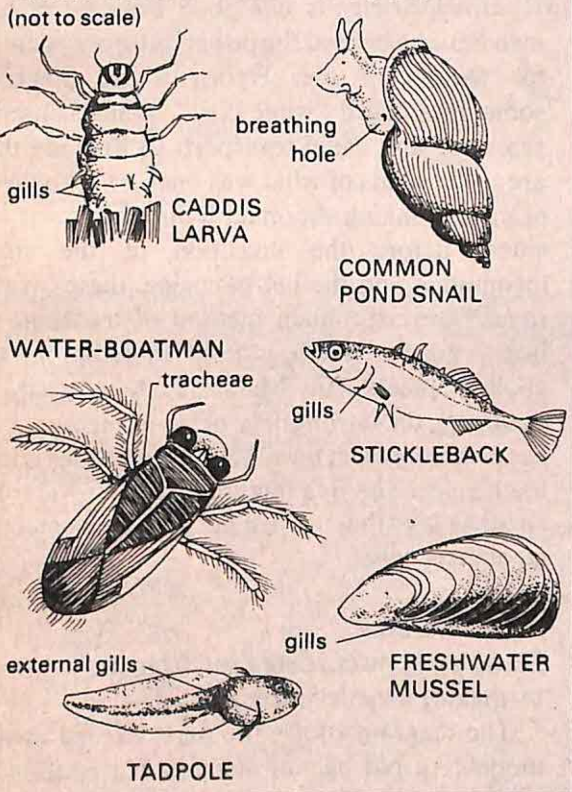
Perhaps you have noticed algae growing on walls and tree trunks. They look like a thin layer of green powder.

AQUARIUM TANK

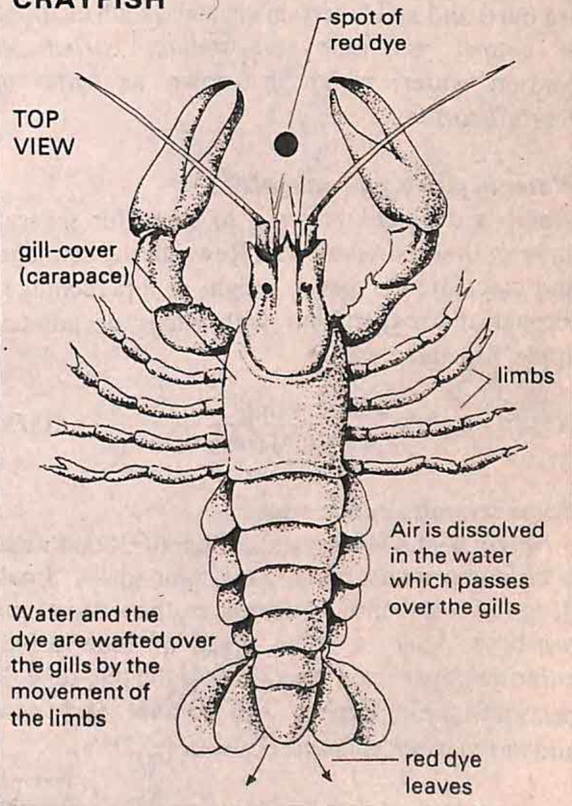


SOME AQUARIUM ANIMALS

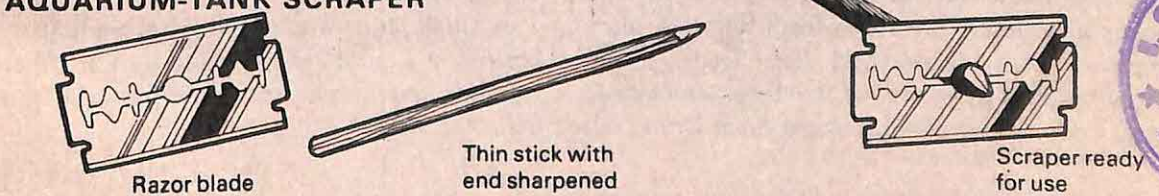
(not to scale)



CRAYFISH


spot of red dye
TOP VIEW
gill-cover (carapace)
limbs
Air is dissolved in the water which passes over the gills
Water and the dye are wafted over the gills by the movement of the limbs
red dye leaves

AQUARIUM-TANK SCRAPER



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8 Water Everywhere

Water everywhere

As well as the water contained in seas and oceans, lakes and ponds, and rivers and underground streams, there is water in plants and animals, soil, certain mineral salts and the air we breathe.

As you already know, water in the atmosphere exists in the form of a vapour. The greater part of plant and animal material is made of water. About 90%, or 9/10, of a cabbage is water. 70%, or 7/10, of a man is water. Even "dry" soil contains small quantities of water. Though they are hard and solid, certain crystals, such as those of *copper sulphate* and *sodium carbonate*, contain water, which is known as *water of crystallization.*

Water in plants and animals

Weigh a cabbage. Allow it to stand for several days so that it dries slowly. Reweigh the cabbage and calculate the loss in weight as a percentage. Repeat this experiment with slices of potato, apple, fish and meat.

$$\text{Loss in weight} = \frac{\text{loss in weight of cabbage}}{\text{weight of fresh cabbage}} \times 100\%$$

Some crystals contain water

Strongly heat a few crystals of copper sulphate in a test-tube made of heat-resistant glass. Small drops of water may *condense* on the sides of the test-tube. Hold a small piece of blue cobalt chloride paper over the mouth of the test-tube. It becomes pink. Repeat with *sodium carbonate* and *magnesium sulphate* (Epsom salts).

Water for life

Water is necessary for life. A man lost without water in a desert soon dies from thirst. A plant without water withers and dies. Seeds do not grow without moisture. Water helps animals to keep cool. When animals sweat, heat from their bodies is used, and so they keep cool. It is for this reason that it is healthy for people, particularly those living in hot climates, to perspire.

The uses of water

Apart from drinking and cooking, water has many other uses. It is used for washing and cleaning. Water-mills were once used for grinding corn. Countries which have fast-moving mountain rivers and waterfalls, such as New Zealand, Norway, Canada, the British Isles and Switzerland, are able to make *hydro-electricity*. Hydro-electricity is one good example of how men have harnessed the powerful forces of nature for their own use. Hydro-electric power is sometimes called "white coal". Water is used in sea, river and canal transport. In England there are the remains of what was once a vast network of canals linking the main industrial towns and cities. Before the invention of the steam locomotive and the petrol-engine, these "water-roads" were the main method of transport for heavy goods. Water is used in radiators and cooling plants. In Malaysia it is used for obtaining tin. Strong jets of water separate the heavy tin ore from unwanted earth. Water is used in chemical and dye factories. In fact, water has so many uses that it is just not possible to mention all of them here.

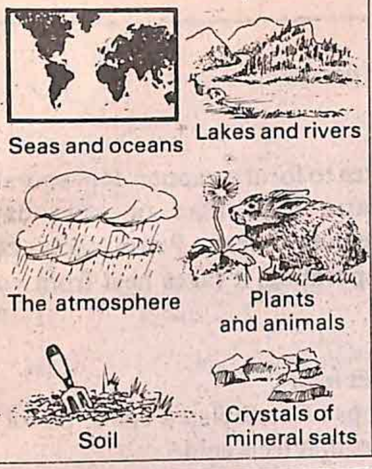
A water turbine

Show how power is obtained from moving water by making a model *water turbine*.

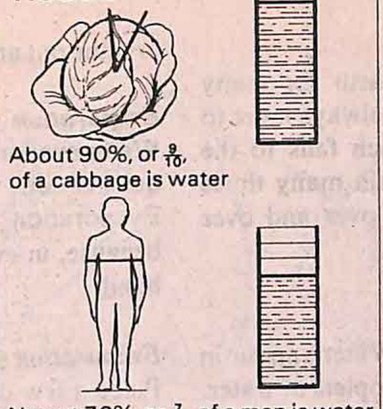
The diagram shows the parts needed for this model. An old pair of scissors can be used for cutting the tinplate, which can be taken from an unwanted metal can.

A small jet of water falling from a hole in the bottom of a large can is used to turn the wheel. If water is too messy, the same principle can be demonstrated by using fine sand.

WATER EVERYWHERE

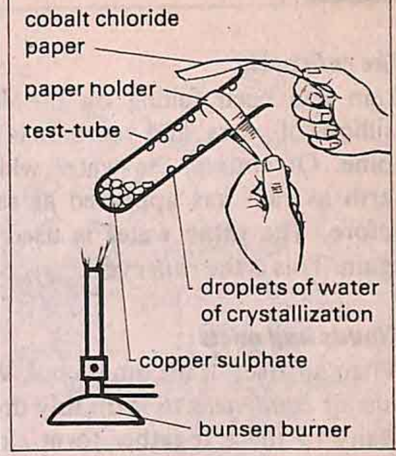


WATER IN LIVING TISSUE

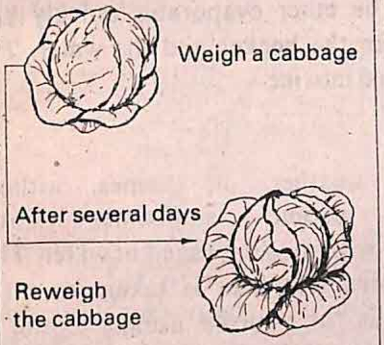

About 90%, or $\frac{9}{10}$, of a cabbage is water

Almost 70%, or $\frac{7}{10}$, of a man is water

WATER IN CRYSTALS

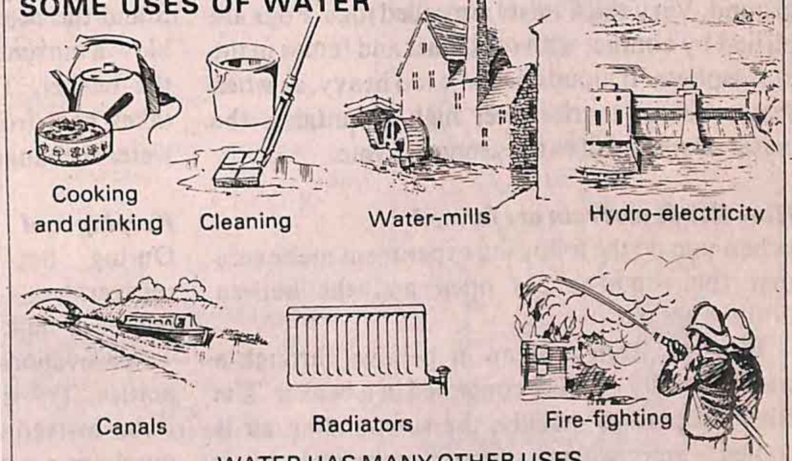


WATER IN PLANTS AND ANIMALS



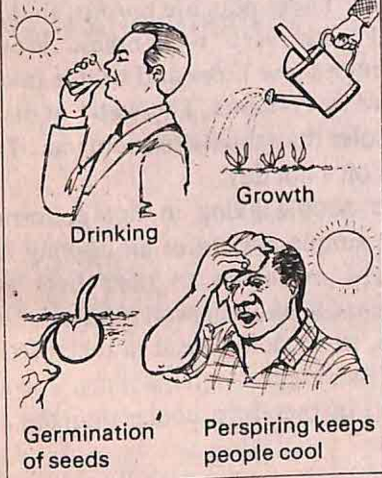
Repeat with potato, apple, fish and meat slices

SOME USES OF WATER

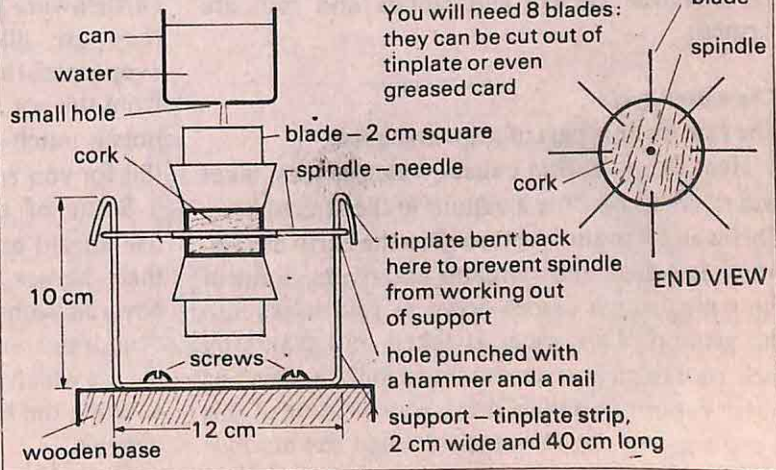


WATER HAS MANY OTHER USES

WATER FOR LIFE



MODEL WATER TURBINE


can
water
small hole
cork
blade – 2 cm square
spindle – needle
10 cm
screws
12 cm
wooden base
tinplate bent back here to prevent spindle from working out of support
hole punched with a hammer and a nail
support – tinplate strip, 2 cm wide and 40 cm long
blade
spindle
cork
END VIEW

You will need 8 blades: they can be cut out of tinplate or even greased card

9 The Water Cycle

The rain cycle

Rain has been falling on the earth for many millions of years, and yet there is always more to come. Of course, the water which falls to the earth as rain has appeared as rain many times before. The same water is used over and over again. This is the *rain cycle.*

Clouds and mists

When air rises, it becomes cool. Water vapour in this air *condenses* to form tiny droplets of water. Many of these together form clouds. Mists are formed when air comes into contact with cold ground. Very thick mists are called fogs. Fogs are dirtied by contact with soot, dust and fumes in the atmosphere. If clouds become too heavy, as when they attempt to rise over high mountains, the water droplets fall to the ground as rain.

How clouds and rain are formed

When you do the following experiment make sure that the windows are open and the bunsen burners are out.

Blow air from a pump or bellows through a small quantity of *ether* contained in a beaker. The ether evaporates quickly, the surrounding air is cooled, and water vapour contained in it condenses on the outside of the beaker.

When air in the atmosphere meets colder air, condensation occurs and clouds and rain are formed.

The water cycle

The rain cycle is part of the *water cycle.*

Heat from the Sun causes water in seas, lakes and rivers to become a vapour in the atmosphere. This water vapour is returned to the earth as rain, which is collected by streams and rivers. Some of the water which comes down as rain soaks into the ground. This water is taken into plants by their roots and is given out through their leaves as water vapour. Animals drink water. Some of this is returned to the atmosphere when the animals breathe out and perspire.

Evaporation

Water evaporates to form a vapour. It evaporates quicker on warm days than on cold days. Evaporation requires heat. Petrol feels cold because, in evaporating, it takes heat from your hand.

Evaporation uses heat

Place a few drops of methylated spirit, petrol or ether on your hand. It feels cold.

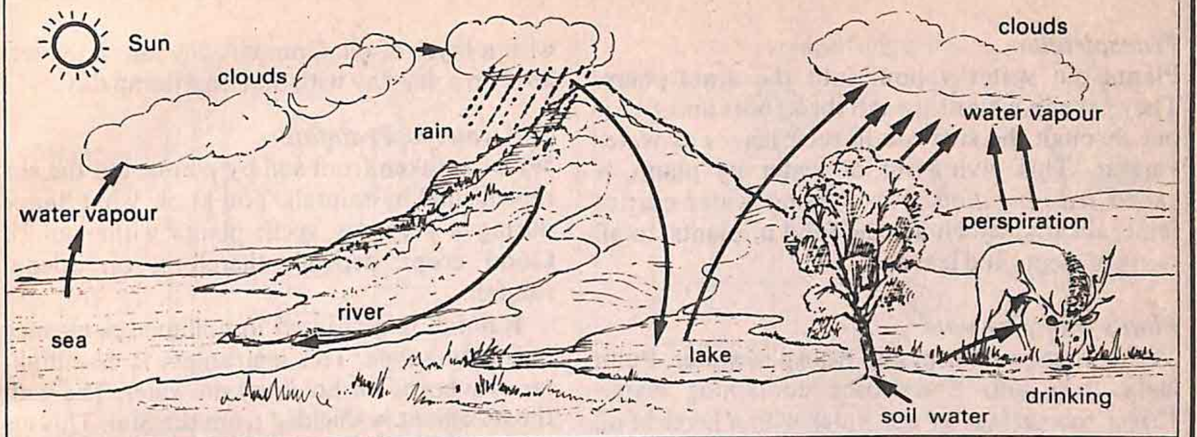
Place a small quantity of ether in a beaker. Stand the beaker in a small pool of water. Then blow a current of air from a pump or bellows into the beaker. The ether evaporates quickly and takes heat from the beaker and the water. The water is changed into ice.

Keeping cool

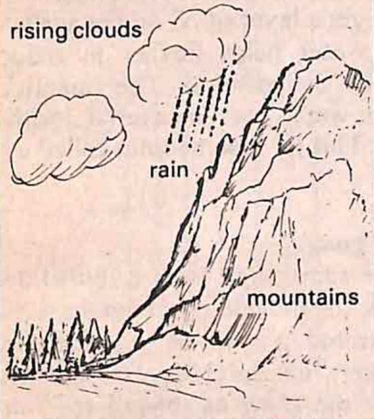
During hot weather, in homes without refrigerators, people sometimes cover bottles of milk with muslin soaked in water. This water evaporates and heat is taken from the bottles. Try this for yourself using a bottle of water instead of a bottle of milk. It is possible to purchase a patent cooler that works in the same way.

In hot countries water is sometimes stored in earthenware pots. These pots are *porous,* that is, they are filled with very tiny holes. Water evaporates through these holes and heat is taken from the pot and its contents. The water in these pots is much cooler than the surrounding air. Try this for yourself on a hot day.

Some of the people living in hot countries use an old and simple system of air-cooling for their homes. The entrances to their huts are covered with mats soaked in water. This water evaporates and, in so doing, heat is taken from the air which is passing through the mats. The air entering the huts is, therefore, cooler than the air outside.

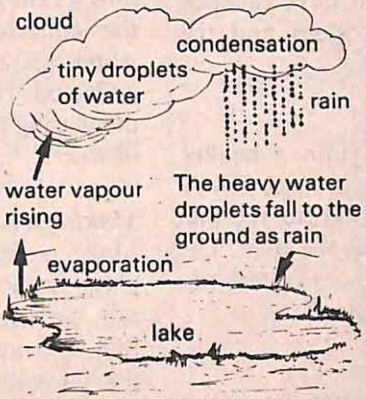


WATER CYCLE

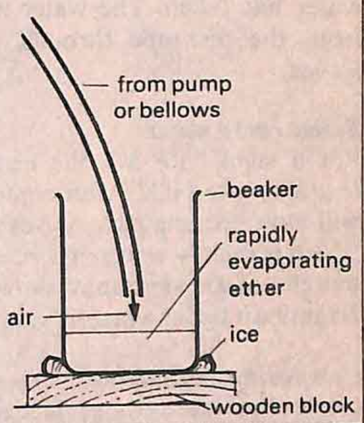


RAINFALL

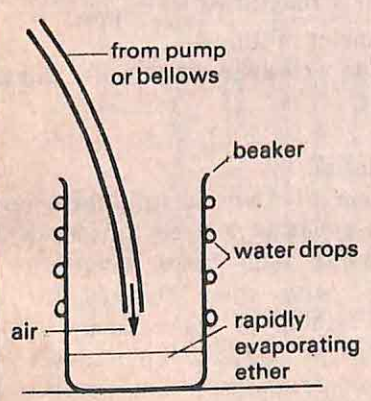
The clouds are forced to rise



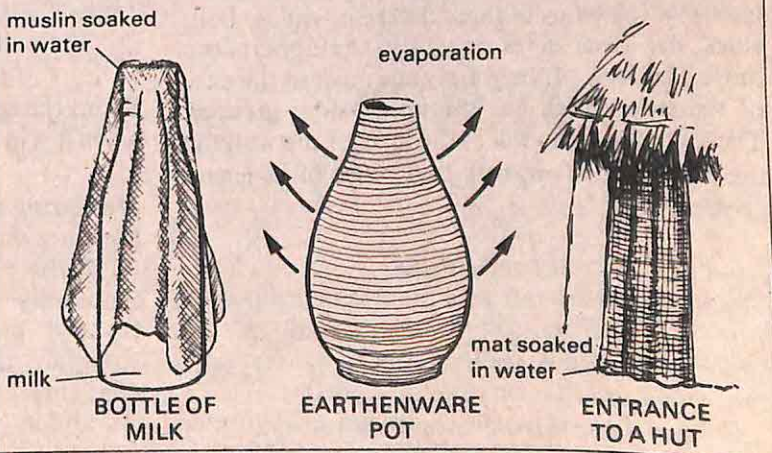
RAIN CYCLE



EVAPORATION USES HEAT



HOW CLOUDS AND RAIN ARE FORMED



KEEPING COOL

10 Water in Plants

Transpiration

Plants put water vapour into the atmosphere. They take in water through their roots and give it out through the stomata in their leaves as water vapour. This giving-out of water by plants is called *transpiration*. The moving water carries mineral salts, which are the food of plants, to all parts of stems and leaves.

Plants transpire water

You can show that plants transpire water. Put a leafy twig into a test-tube containing water. Cover the surface of the water with a layer of oil to prevent water being lost from the test-tube by evaporation. Allow the test-tube to stand for a few days. Then you will notice that the level of the water has fallen. The water must have escaped from the test-tube through the stem and the leaves.

Stems carry water

Put a stem with a white flower into a beaker containing red ink. After some hours, the flower will have become pink, showing that the red ink, which is mainly water, has risen up the stem. The cut end of the stem may show traces of red ink. Examine it under a magnifying glass.

Comparing leaf surfaces

Generally, more water is transpired from the lower side of a leaf than from the upper side. Place three leafy twigs in separate test-tubes containing water and a layer of oil. Grease the leaves of the twigs in three different ways—both sides, the lower sides only, and the upper sides only. The level of the water falls most in the case of the twig which has the upper sides greased. There is little or no fall in the level of the water in the case of the twig with both sides of its leaves greased.

Humidity controls transpiration

The transpiration rate of a plant is controlled by *humidity*, that is, the water content of the atmosphere. Transpiration is much quicker on a dry, windy day than on a damp, calm day.

Put a leafy twig in a test-tube containing water with a layer of oil. Compare the fall in the water level on a dry day with that on a damp day.

Soil water and rainfall

Water is taken from soil by plants, but the soil is replenished by rainfall. You know what happens during a very dry spell; plants wither and die. Good crops depend, therefore, on adequate rainfall.

Rainfall is measured in millimetres by means of a *rain-gauge*. This instrument is essentially a jar or a bottle for holding rain-water. The wall of the container is shielded from the Sun. This helps to prevent water losses by evaporation. Rain falls into a funnel. This funnel also helps to reduce water losses by evaporation. Oil is sometimes put into a rain-gauge; a layer of oil on the surface of the collected water helps further in reducing water losses by evaporation. The quantity of collected rain-water is measured with a measuring jar. This jar is sometimes called a *rain measure*.

Making a rain-gauge

Make a simple rain-gauge from a funnel and a glass jar. Paint the outside of the jar so that the rain-water collected in it will be shaded from the Sun. It is not likely that the cross-sectional area of the jar will be the same as that of the funnel. Therefore, to find the rainfall, pour the collected water into a measuring jar. Then find the actual rainfall by means of this calculation:

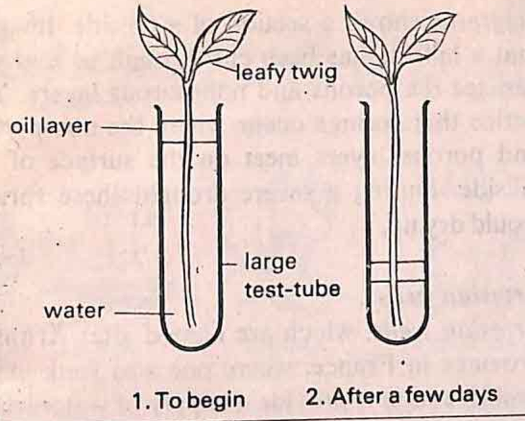
$$\text{Rainfall} = \text{height of water (in mm) in measuring jar} \times \frac{(\text{diameter of measuring jar})^2}{(\text{diameter of funnel})^2}\ \text{mm}$$

Stand the gauge well away from walls and trees when it is in use.

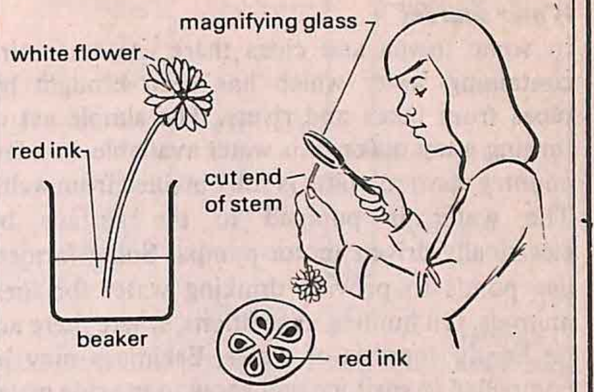
Measuring rainfall

Measure the rainfall in your district for a month. Read the rain-gauge at a fixed time each day. Show the rainfall with block diagrams; use squared paper with small squares for this. Compare the rainfall of your district with an official record of the average rainfall for the same month for the whole country.

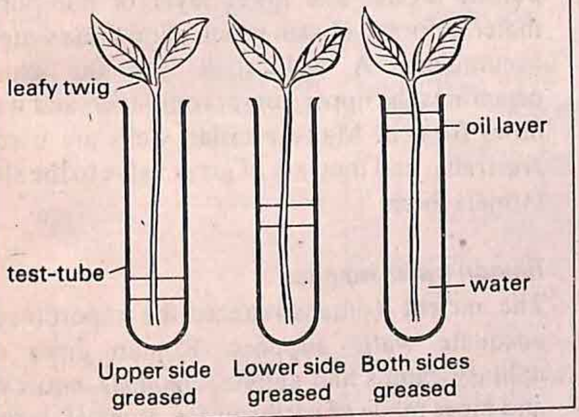
PLANTS TRANSPIRE WATER



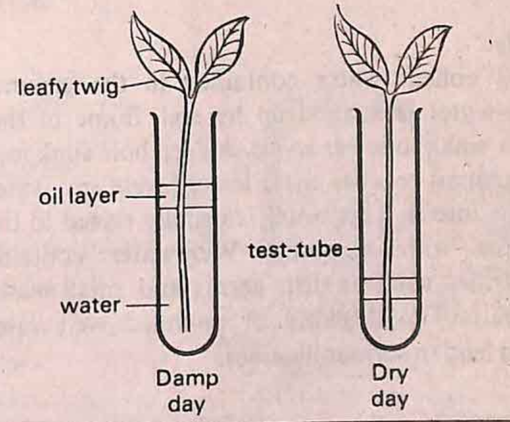
STEMS CARRY WATER



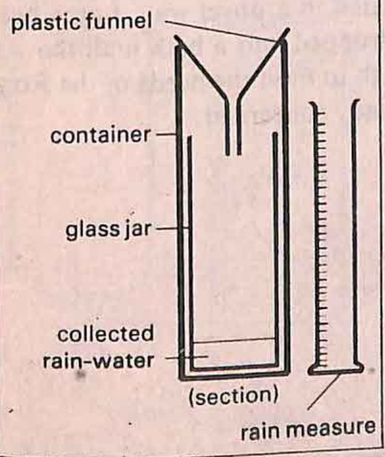
COMPARING LEAF SURFACES



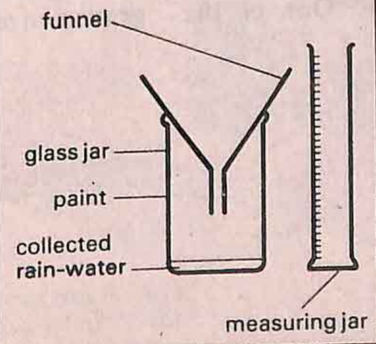
HUMIDITY CONTROLS TRANSPIRATION



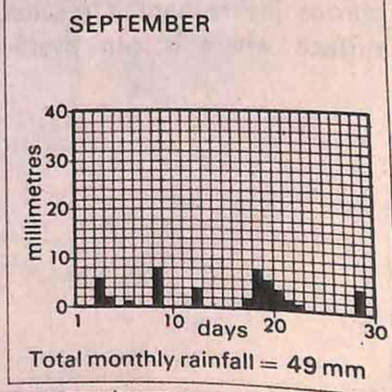
RAIN-GAUGE



MAKING A RAIN-GAUGE



MONTHLY RAINFALL CHART



11

Water Supplies

Water sources

In some towns and cities there are reservoirs containing water which has been brought by pipes from lakes and rivers. The simple act of turning a tap makes this water available. In a few country districts water is still obtained from wells. The water is pumped to the surface by electrically-driven motor-pumps. Some farmers use ponds to provide drinking water for their animals. On hunting expeditions, where there are no handy supplies of water, Eskimoes may be compelled to melt ice and snow to provide water for drinking and cooking. Desert people depend upon isolated *oases*. Water that is suitable for drinking can be made from sea-water.

Wells

Wells collect water contained in the ground. Rain-water is soaked up by soil. Some of this water sinks to lower levels. A deep hole sunk into the ground reaches these lower levels and water drains into it. This water is usually raised to the surface with a pump. Well-water contains impurities such as dirt, germs and small water animals. The drinking of unboiled well-water could lead to serious illnesses.

Springs

A spring is simply the appearance of water contained in the ground. Rain-water seeps through *porous* layers in the earth until it meets a *non-porous* layer. This water accumulates in the porous layers until it reaches a point on the surface where it can overflow. One of the diagrams shows a section of a hillside. Imagine that a hillside has been cut through so that you can see the porous and non-porous layers. You notice that springs occur where the non-porous and porous layers meet on the surface of the hillside. During a severe drought these springs would dry up.

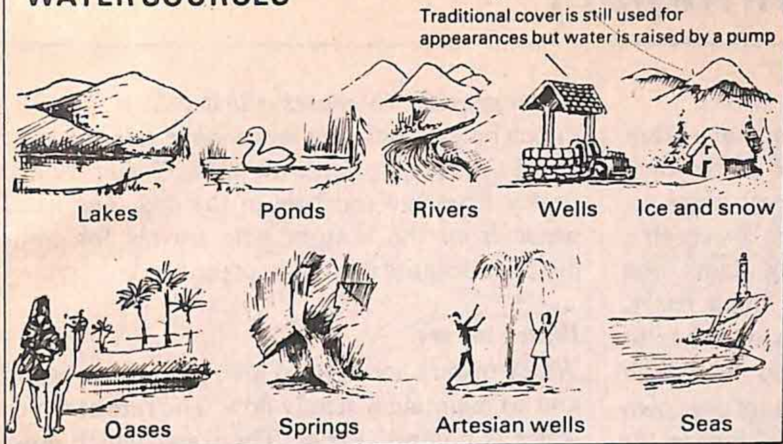
Artesian wells

Artesian wells, which are named after Artois, a province in France, where one was sunk in the twelfth century, provide a supply of water which rises to the surface automatically. One of the diagrams shows a section of a valley. Rain falls in the surrounding hills and is soaked up by the porous layers. The lower layer of non-porous material forms a basin which allows this water to accumulate. A well sunk into the ground penetrates the upper non-porous layer, and water flows from it. Many artesian wells are used in Australia, and they are of great value to the sheep farmers there.

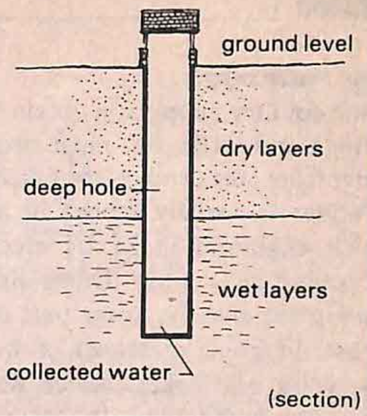
Roman water supplies

The ancient Romans realized the importance of adequate water supplies. Roman cities and military camps had gutters, channels, aqueducts and pipes made of earthenware, stone and wood. Villas, the large mansions which belonged to wealthy Romans, had baths. The water in these baths was heated in a novel way. Large heated stones were dropped into a bath until the water was hot enough to meet the needs of the Roman gentleman or lady concerned.

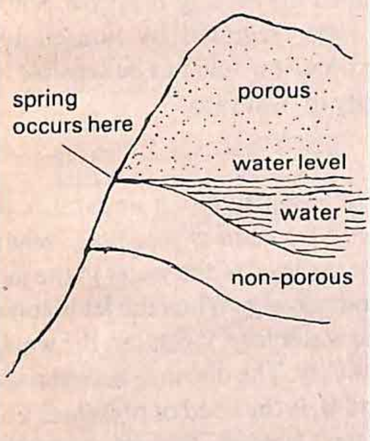
WATER SOURCES


Traditional cover is still used for appearances but water is raised by a pump
Lakes
Ponds
Rivers
Wells
Ice and snow
Oases
Springs
Artesian wells
Seas

WELL

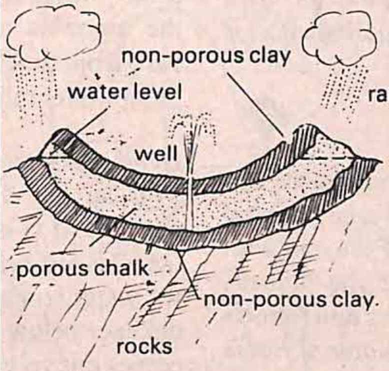


SPRING

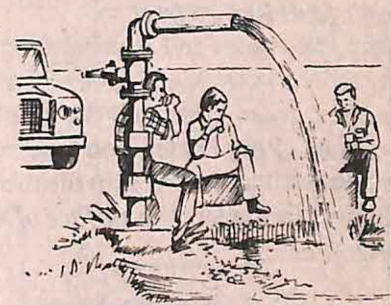


Section through a hillside

ARTESIAN WELL

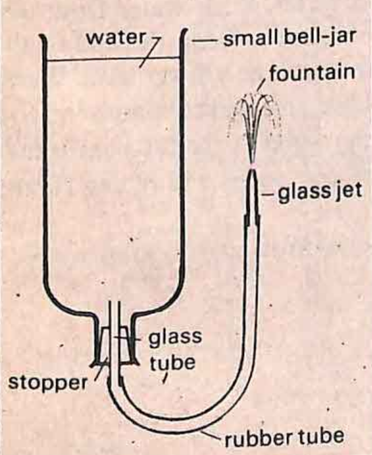


Section through a valley

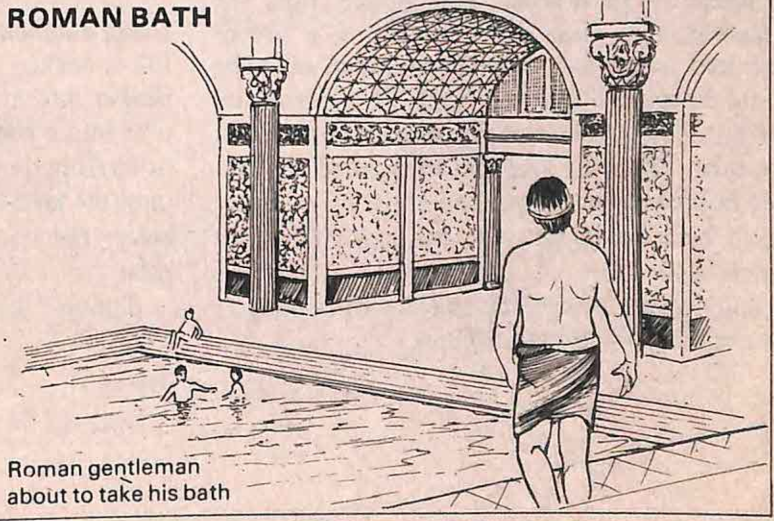


Artesian well in Australia

ARTESIAN FOUNTAIN



ROMAN BATH



Roman gentleman about to take his bath

12

Your Water Supply

Your water supply

Some country people still obtain their water from springs and wells, but most people obtain their water from lakes and reservoirs through pipes.

Water is usually stored in large reservoirs, which engineers make by erecting dams and deepening river beds. Dams have thick bases. This is because the lower part of a dam has to withstand great *pressures* of water. With high reservoirs and lakes, water flows of its own accord to the houses in the towns. Otherwise, the water is pumped into water-towers or small reservoirs that are at a height. Water-flows from these towers and reservoirs under its own pressure, that is, no pumping is required. *Water tries to find its own level.*

Water finds its own level

Insert glass tubes and funnels of various sizes and shapes into holes made in the lid of a large metal can. Seal these holes and the lid of the can with plasticine. Pour water into one of the funnels. You notice that the water in the tubes and funnels is at the same level. *The surface of water at rest is horizontal.*

Using a spirit-level

Examine a spirit-level. You notice that the indicator is a glass tube containing a green-coloured liquid and a small bubble of air. The liquid is spirit. Place the level on a horizontal surface. The bubble occupies a central position in the tube. Place the level on an inclined surface. The bubble travels to one end of the tube. Water could be used in the tube but spirit does not "stick" to its sides.

Spirit-levels are used by builders and engineers for checking horizontal surfaces.

Water pressure increases with depth

Punch holes at different levels in the side of a large metal can. Fill the can with water. Water trickles slowly from the top hole in the can. The jet of water from the bottom hole travels for some distance because it is under pressure.

Water-towers

Water-towers are used to give pressure to water and so maintain a steady flow. The rate at which water is pumped varies. The water which flows from the tank in a tower is at an even pressure. This pressure depends upon the height of the tower, which is called the *head of pressure*. Since the amounts of water required by households vary from time to time, it would not be sensible to pump water directly to their taps.

Head of pressure

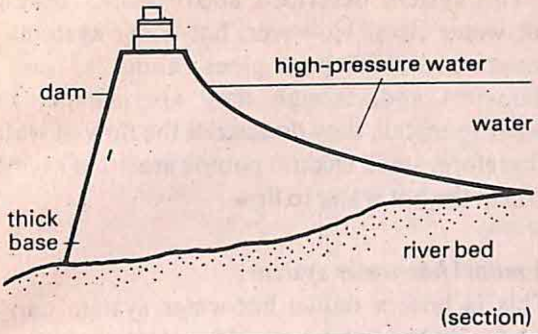
You can use the artesian fountain apparatus to show what is meant by *head of pressure*. When the jet is just below the level of the water in the jar, the water comes out slowly. When the jet is some distance below the water level in the jar, the water comes out very quickly. The distance between the water levels, A and B, is the head of pressure. The force of the water leaving the jet depends, therefore, on the head of pressure.

Using a siphon

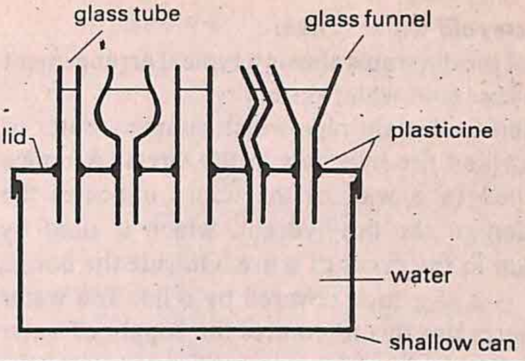
Fill a beaker with water. Suck water from this beaker into a rubber tube. Drop the end of the tube into a beaker placed at a lower level. Water flows from the rubber tube and continues to do so until the level of the water in the top beaker falls below the level of the upper end of the rubber tube.

Siphons are sometimes used to move water over hills.

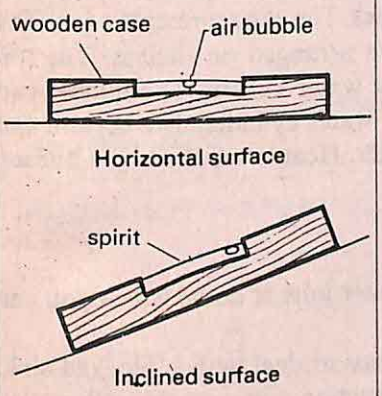
DAM



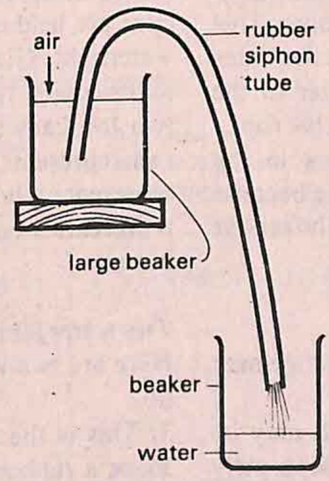
WATER FINDS ITS OWN LEVEL



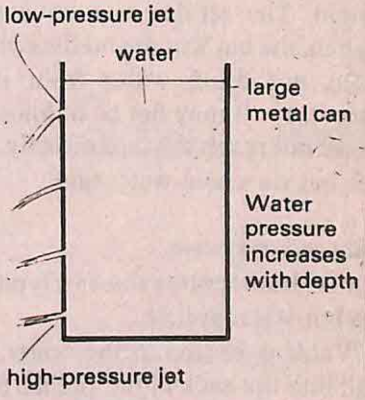
SPIRIT-LEVEL



SIPHON

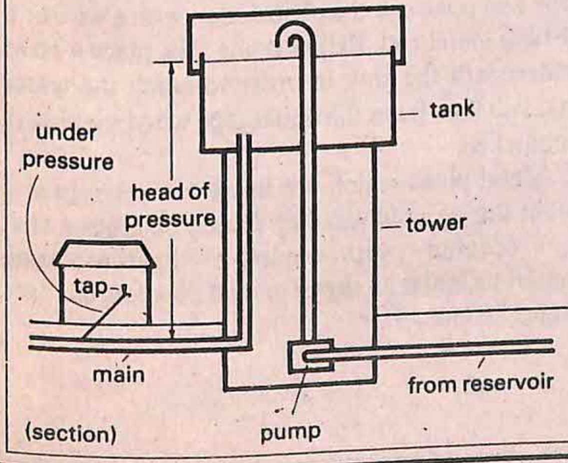


DEPTH AND PRESSURE

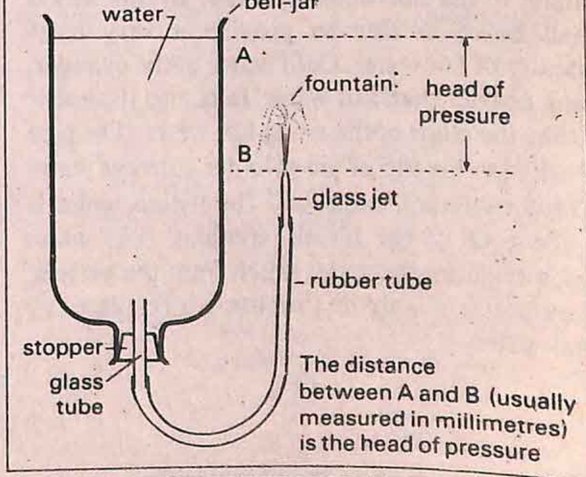


Water pressure increases with depth

WATER-TOWER



HEAD OF PRESSURE



The distance between A and B (usually measured in millimetres) is the head of pressure

13 A House Water System

A house cold-water system

One of the diagrams shows a typical arrangement of a house cold-water system.

There is a main pipe which supplies water to houses and fire-hydrants in the street. A notice attached to a wall of the house indicates the position of the fire-hydrant, which is used by firemen in the event of a fire. Outside the house, there is a stopcock covered by a lid. The water engineers use this to control the supply of water to the house. A service pipe carries water into the house. There is a stop tap, usually near the kitchen sink, which enables the householder to turn off the water to the whole of the house. This stop tap is very useful if a leak occurs in the water system. The service pipe conveys water to the kitchen, the bathroom and the cistern in the roof.

Do *not* drink water from the taps in the laboratory. It may not be fit for drinking because it may not reach the taps directly from the service pipe but via a cold-water tank.

A hot-water system

One of the diagrams shows a typical arrangement of a hot-water system.

Water is heated in the boiler, which may be built into the back of the kitchen fire or separately heated by gas, oil or solid fuel. Hot water, being lighter than cold water, rises and enters the pipe leading to the hot-water cylinder. In this way a small boiler is able to provide a very large quantity of hot water. Cold water in the cylinder, being heavier than hot water, falls into the boiler to take the place of the rising hot water. The pipe attached to the top of the cylinder conveys water to taps, radiators, baths, etc. The cistern, which is in the roof of the house, contains cold water which replaces the water taken from the system. The amount of water in the cistern is regulated by a ball-valve.

The system described above works because hot water rises. However, hot-water systems in houses use small bore pipes (about 13 mm in diameter) and, though they are cheaper and easier to install, they do restrict the flow of water. Therefore, small electric pumps are fitted in order to help the hot water to flow

A model hot-water system

This is how a model hot-water system can be made. Copper tubes are soldered into holes in the sides of three large metal cans in the manner shown in the diagram. The lids of the two lower cans are held in place with solder. They must be watertight. Glass and rubber tubes are attached to the copper tubes. The clip represents a tap. The two top cans are arranged on shelves. The top can represents a water cistern. The middle can represents a hot-water cylinder. The bottom can represents a boiler. Heat is supplied by a bunsen burner.

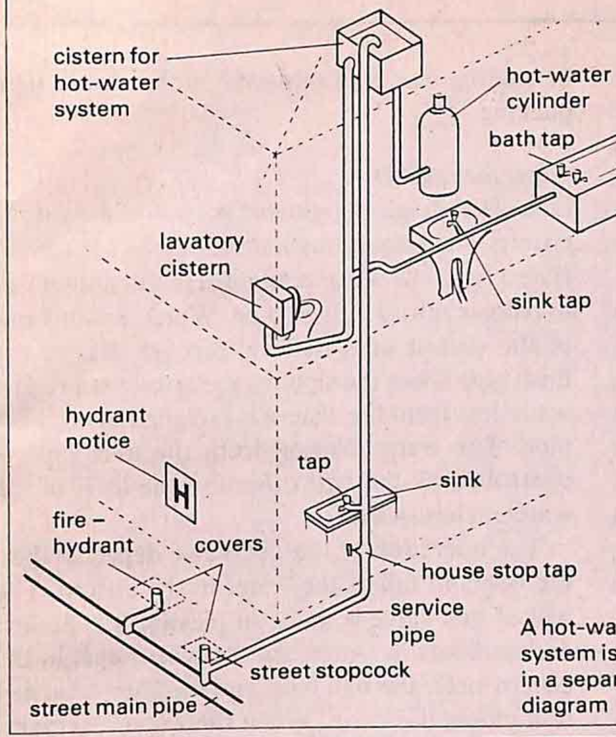
Two water jobs

Here are two water jobs at home which you can do.

1. This is the way to deal with a blocked sink. Place a rubber suction cup over the sink outlet. Press it down and pull it up sharply. Repeat this process several times. If this fails to unblock the sink, remove the screw at the bend in the outlet pipe and poke out the obstruction with a wire or a flexible metal rod. Before doing this, place a bowl underneath the sink in order to catch the water that will flow from the outlet pipe when the sink is unblocked.

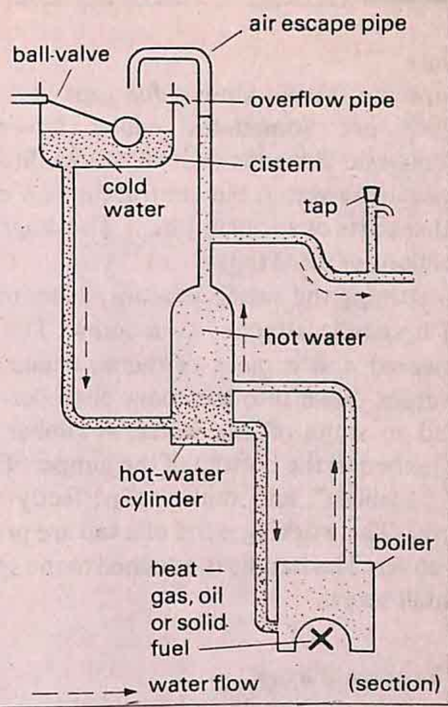
2. Metal pipes which are liable to freeze up and burst during cold weather should be *lagged*, that is, covered with suitable heat-insulating materials, such as rags, foamed plastics, etc. (see pages 36 and 38).

HOUSE COLD-WATER SYSTEM

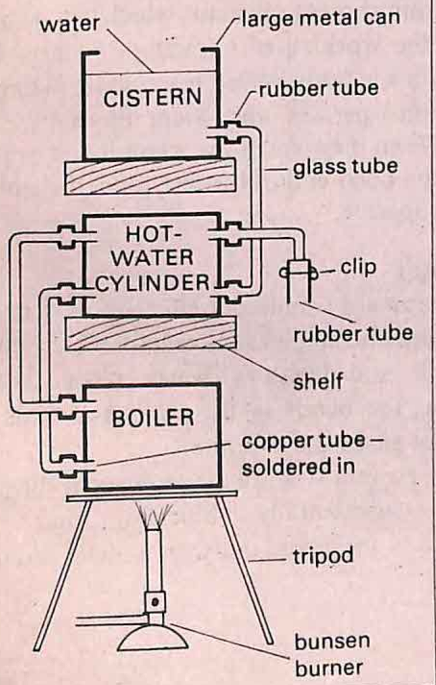


A hot-water system is shown in a separate diagram

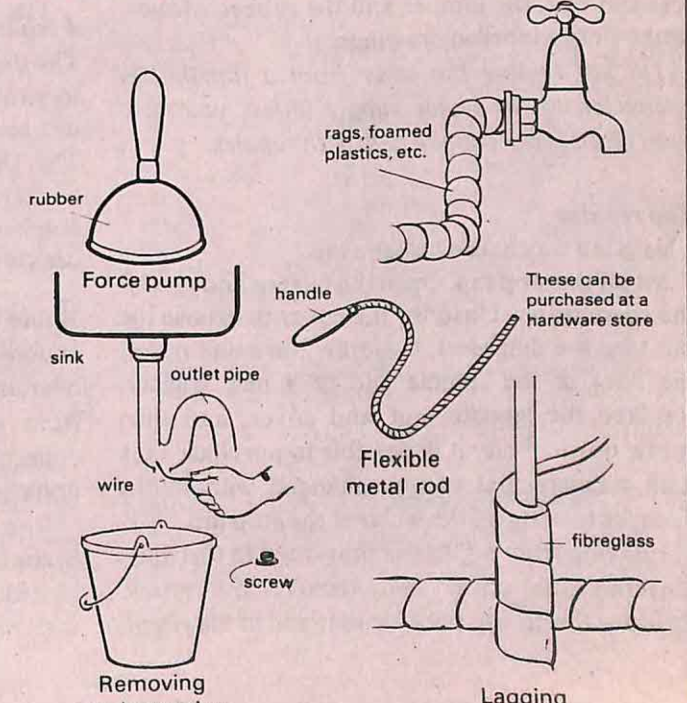
HOT-WATER SYSTEM



MODEL HOT-WATER SYSTEM



TWO WATER JOBS



Removing an obstruction

Lagging

14 Water Fittings

Taps

Taps are of two kinds—*bib taps* and *stop taps*. They are sometimes called *bib-cocks* and *stopcocks*. Bib taps provide water. Stop taps do not release water, but control the flow of water to other parts of a water system. The diagrams show sections of these taps.

Turning the handle of a tap causes the rotation of a spindle attached to a screw. The spindle is lowered and a piece of metal, called a *jumper*, presses down into the main chamber of the tap and so shuts off the water. A rubber washer is attached to the bottom of the jumper. This acts as a "cushion" and makes a perfectly watertight joint. The working parts of a tap are protected by a cover. The handle is attached to the spindle by a small screw.

The parts of a tap

Remove the handle and cover of a spare tap and examine its parts. Notice the spindle with its screwed end, the jumper and the rubber washer. Make simple labelled drawings.

Do not remove the cover from a tap that is connected to the water supply unless you have been given permission to help with repairs.

Tap repairs

This is the way to re-washer a tap.

Turn off the stop tap. Open the bib tap and run off the spare water. Unscrew the cover to expose the nut (see the diagram). Unscrew the small nut at the base of the spindle and fit a new washer. Replace the spindle, nut and cover, and then screw down. *Note:* it is possible to purchase taps with washers that can be changed without the need for turning off the water at the stop tap.

Leaking from a gland is prevented in this way. Unscrew the cover and remove the screw. Remove the greasy packing material in the *gland*, or *stuffing-box*, and replace it with a fresh, tight packing.

A lavatory cistern

One of the diagrams shows a section of a lavatory cistern. Depressing the handle causes the *siphon bell* to rise. The water contained in the siphon bell overflows into the *flush pipe*. Water siphons out of the cistern until its level reaches that of the flush pipe. Then the siphon ceases to operate. The water lost from the cistern is replaced by the inlet pipe. The water flowing from the inlet pipe is controlled by the *ball-valve* and the level of the water in the cistern.

The operation of the ball-valve depends upon the rise and fall of the water in the cistern. The ball of this valve is made of plastic. It is hollow and so floats in water. As the water level in the cistern rises, the ball rises and the *lever* attached to it closes the valve. When the water level falls, the ball falls and the lever pulls the valve open.

A model lavatory cistern

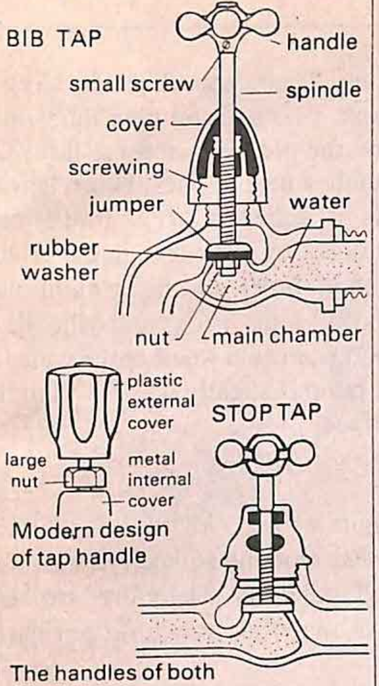
The diagram shows apparatus which can be used to show the working of a lavatory cistern. The test-tube is suddenly raised for a short distance. The siphon operates and water flows into the beaker. When the level of the water in the bell-jar reaches the open end of the test-tube, the siphon ceases to operate.

Water traps

Water traps are simple but effective devices for overcoming the unpleasant smells which come from sink and lavatory waste pipes. Water collects at the bends in the pipes and seals off unpleasant gases and vapours.

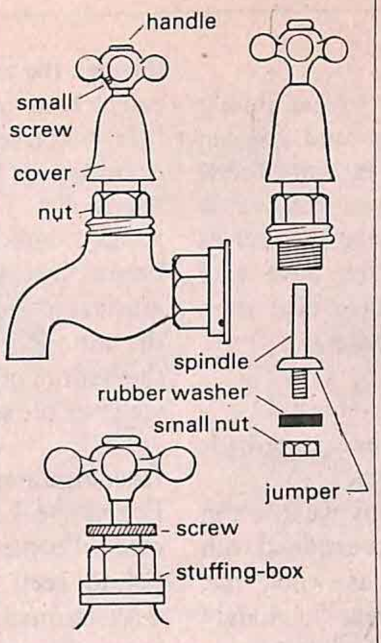
The screw in a sink trap is removed if the pipe becomes accidentally blocked, and the obstructions are poked out with a metal rod or a stiff wire.

TAPS



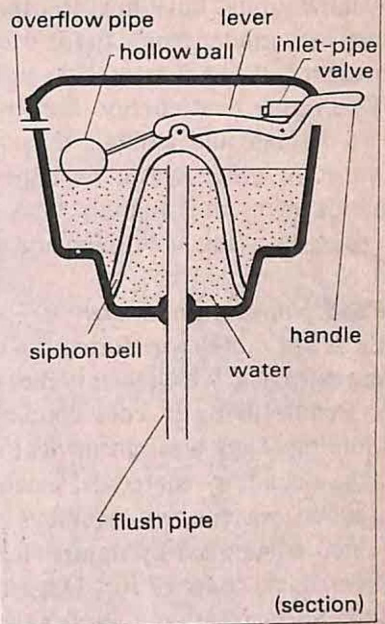
The handles of both taps are turned clockwise to shut off the water

THE PARTS OF A TAP

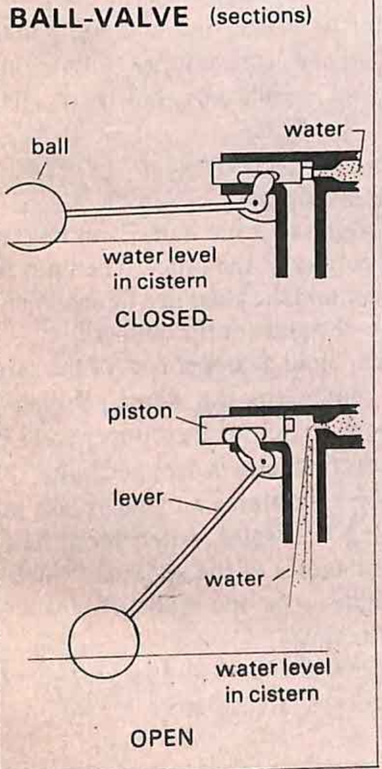


There is some variety in the designs of taps. A typical design is shown here.

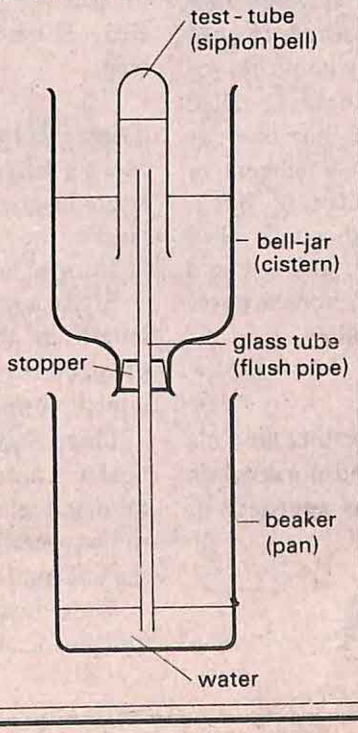
LAVATORY CISTERN



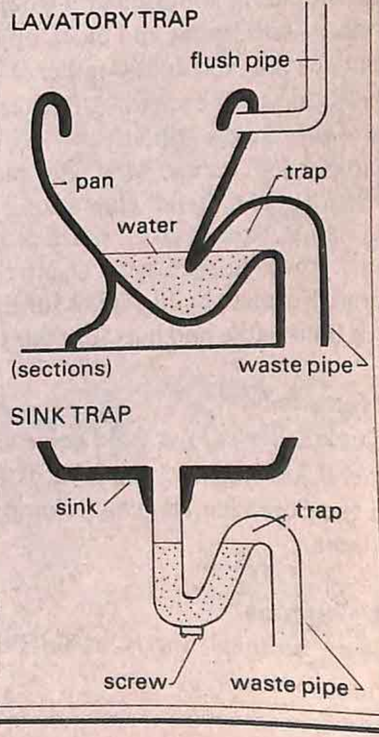
BALL-VALVE



MODEL LAVATORY CISTERN



WATER TRAPS



15 Keeping Warm

Animals must keep warm

Animals must have heat in order to live. Bodily heat is made from food eaten and oxygen breathed. Sugars, starches and fats are foods which give heat energy. Sometimes this heat is not enough and animals must keep themselves warm in other ways. Perhaps you have read about men and animals who have died from exposure—lack of clothing and shelter.

Food, clothing and shelter

Birds eat more food during the winter to provide the extra heat which their bodies need.

People living in cold conditions wear warm clothing. They wear garments that are lined with heat-insulating materials, such as wool, fur, foamed plastics, etc. Animals wear "clothing" which is supplied by nature. Rabbits and hares have thick coats of fur. Dogs and horses have hair. Sheep have wool. Birds have feathers.

Animals find shelter from the severe cold of winter. Rabbits live in burrows. Badgers dig out deep holes in a hillside or a wood. They line their homes with leaves and block up passages to keep out enemies and cold weather. They come out for food during fine spells. A badger's home is called a *sett*. Foxes often use rabbit burrows as temporary homes. Men, the most intelligent of the animals, build elaborate houses of brick, concrete, stone, steel, plastics and wood. They heat their houses with electricity, gas, oil and coal. Farmers build stables for their horses, byres for their cattle and huts for their poultry.

Migration

Cuckoos, swallows, wild geese and other animals travel, or *migrate*, southwards (and northwards in the Southern Hemisphere) on the approach of winter.

Hibernation

Many animals find suitable shelters and sleep through the winter. Their deep, deathlike sleep is called *hibernation*. The squirrel hibernates in a hole in a tree or the old nest of some bird. On occasions he builds a nest of bark, twigs, leaves, moss, etc. This is called a *drey*. Bats sleep, hanging upside down by their feet, in caves and barns. Insects find holes in the ground and crevices in rocks and walls. Frogs and fishes lie at the bottom of ponds; in cold weather the water at the bottom of a pond is slightly warmer than the water on the surface.

Heat insulators

People speak, quite wrongly, of "keeping out the cold". People wear clothing to keep in heat and not to keep out coldness. Therefore, clothing must be made of materials which do not carry heat well.

Such materials are called *heat insulators* or *non-conductors of heat*. Some good heat insulators are wool, clay, straw, hay, wood, cork, rubber, snow, fur, feathers, hair and some man-made fibres. Metals—iron, copper, aluminium, etc.—are not heat insulators; they carry heat well.

Three good heat insulators

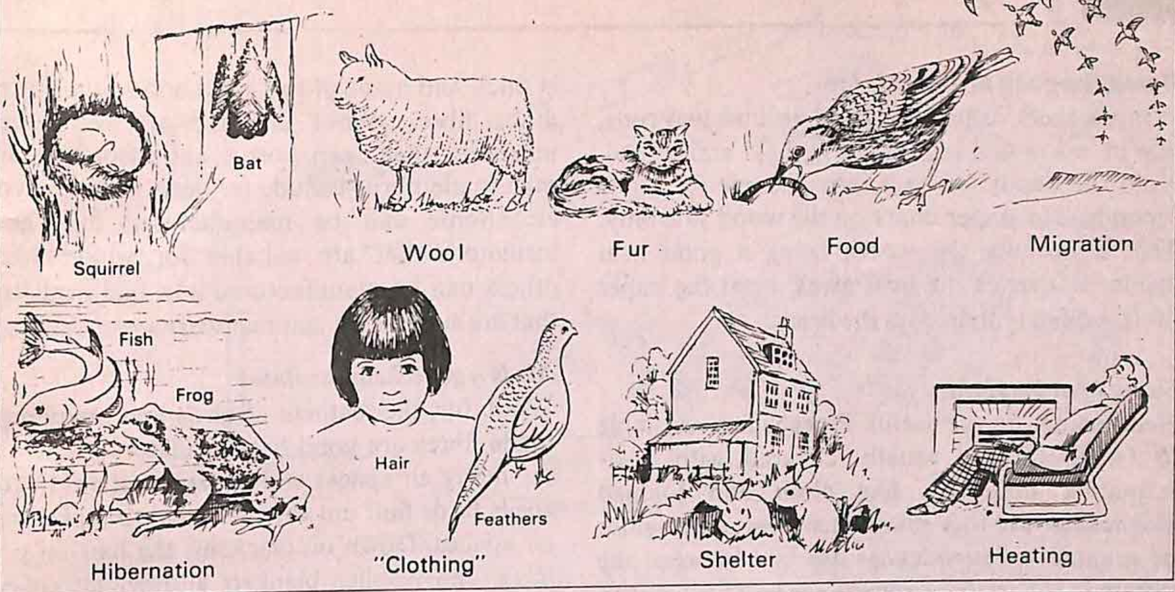
Hold a length of glass in one hand, and hold an equal length of copper in the other. Then put the ends of the copper and the glass in a flame. Which is dropped first—the glass or the copper?

Strike a match. Hold a copper rod, of the same length as the match, in the flame. Which is dropped first—the match or the copper rod? Of course, the better conductor is dropped first.

Place a plastic spoon and a metal spoon in a beaker containing hot water. After about half a minute, feel the handles of the spoons. Which is the warmer handle—the one made of plastic or the one made of metal?

These three experiments show that glass, wood and plastic are good heat insulators.

KEEPING WARM



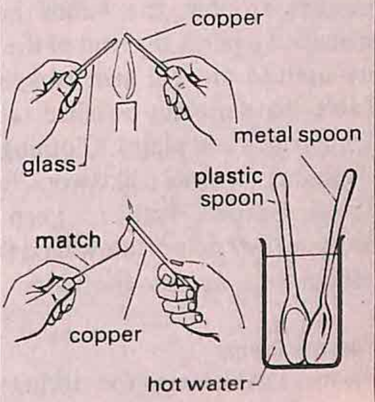
BADGER

A badger outside its sett

WARM CLOTHING

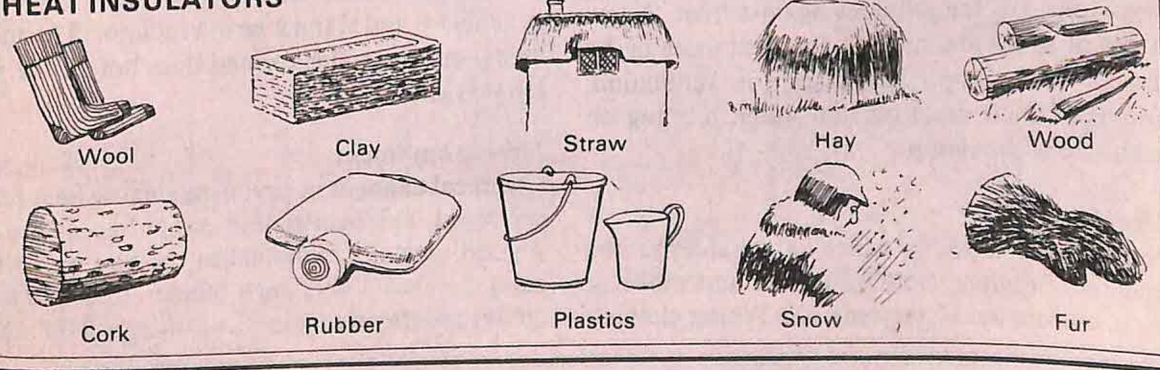
People wear thick or special clothing to keep warm

THREE GOOD HEAT INSULATORS



Which is dropped first?

HEAT INSULATORS



16 Heat Insulators

Wood is a good heat insulator

Wrap a sheet of paper tightly around two rods, one of wood and one of brass, held end to end. Hold the combined rods over a flame for a few seconds. The paper chars on the wood side only. This is because the wood, being a good heat insulator, carries the heat away from the paper far less quickly than does the brass.

Using heat insulators

Heat insulators are useful. Pipes which are liable to freeze up are usually covered with heat-insulating materials, like cloth and foamed plastics, so that they retain their heat. *Fibre-glass* or granules of *vermiculite* are laid between the rafters in the roofs of some houses. This helps to keep the houses warm in winter and cool in summer. Soldering-irons have wooden or plastic handles so that the hands holding them are protected against the heat of the irons. Tea cosies are used to prevent heat escaping from teapots. Table mats protect polished tables against heat from dishes and plates. Clothing is made of heat-insulating materials, like wool, fur and man-made fibres. Carpets help to keep the feet warm because they do not allow heat from the feet to be conducted away into the floors.

Potato clamps

Farmers use *clamps* for storing potatoes. A long heap of potatoes is made. This heap is covered with a layer of straw and a layer of soil. The soil holds the straw and the potatoes in position. The straw protects the potatoes against frost. A few wisps of straw are inserted here and there in the top of the clamp. These are for ventilation. Ditches, which drain off rain-water, are dug on each side of the clamp.

Clothing

People wear clothing which is suitable for the weather. Summer clothing is thin and made of linen, cotton, nylon, terylene, etc. Winter clothing is thick and made of fur, wool and suitable man-made fibres. Wool and fur are better heat insulators than linen, cotton and nylon. Modern man-made fibres include terylene, nylon, rayon, etc. Some can be manufactured into good insulators that are suitable for winter wear; others can be manufactured into bad insulators that are suitable for summer wear.

Air is a good heat insulator

Wool, fur, the feathers of birds and many man-made fibres are good heat insulators because of the many air spaces which they contain. In cold spells birds fluff out their feathers to make more air spaces. Down on chickens, the hair on your head, and woollen blankets all have air spaces. Eiderdowns are so named because they were once filled with down from the *eider duck*. Nowadays, eiderdowns are usually filled with wool or artificial fibres. Though snow feels cold to the hand, it is a good heat insulator because of the many air spaces it contains. Snow is nature's way of providing a protective blanket for the delicate plants and seeds which lie just beneath the surface of the ground.

Air helps considerably in preventing wastage of heat in centrally-heated buildings, for the air between the panes of glass in double-glazed windows, the many air spaces in *polystyrene* wall tiles and the foamed-plastic fillings of wall cavities are excellent heat insulators.

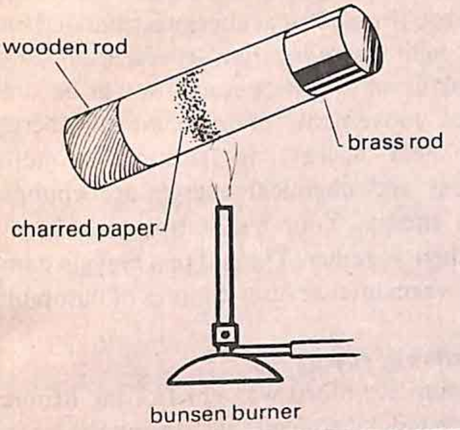
The air spaces in snow

Fill a jar with snow—if some snow is available—and stand it near a radiator. The snow melts, but the water formed does not fill the jar. Do you know why?

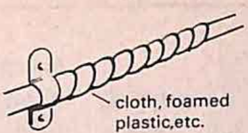
Fires in haystacks

Chemical changes in drying hay cause heat to be produced. This heat cannot escape because hay is a good insulator. Sometimes the hay inside the stack reaches a very high temperature and then ignites *spontaneously*.

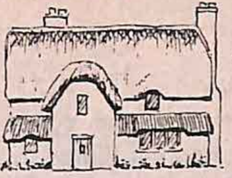
WOOD IS A GOOD HEAT INSULATOR



USING HEAT INSULATORS


cloth, foamed plastic,etc.

Lagged pipes

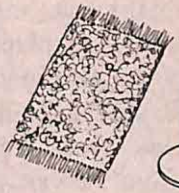


Insulated roofs

Soldering-irons

Teapot handles

Tea cosies



Carpets and rugs

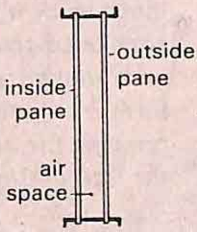
Table mats

CLOTHING

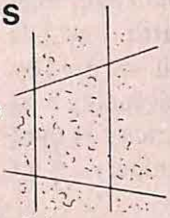
SUMMER
Thin linen,
cotton,
nylon,
terylene, etc.

WINTER
Thick wool,
fur, suitable
man-made
fibres, etc.

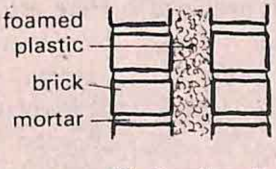
HEAT INSULATION IN BUILDINGS



Double-glazed window

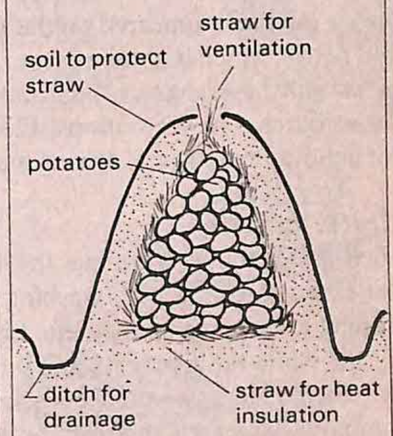


Polystyrene wall tiles



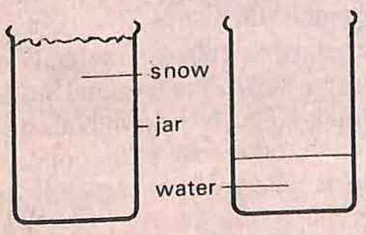
Filled wall cavity

POTATO CLAMP



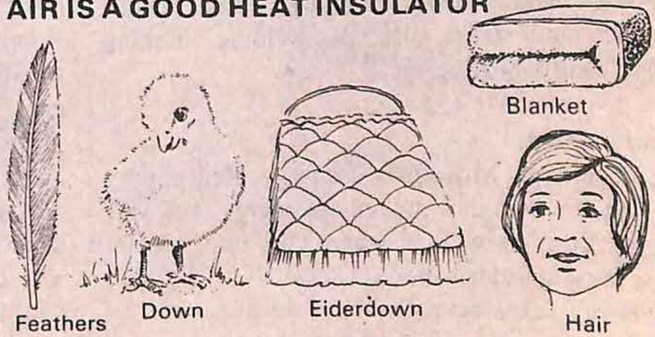
(section)

THE AIR SPACES IN SNOW



1. Before melting
2. After melting

AIR IS A GOOD HEAT INSULATOR



Blanket

Feathers

Down

Eiderdown

Hair

Small air spaces act as heat insulators

17 Heat Energy

Heat from the Sun

The heat which you use comes, directly or indirectly, from the Sun. Plants trap light *energy* in sunshine and use it in making starches and sugars. These supply you with heat energy; they are contained in the fruits and vegetables you eat. Also, many animals eat plants and, in turn, some of them supply you with energy-giving and body-building foods, such as milk, fats, butter, eggs, cheese and meat. Coal, oil and natural gas have been formed from the vast primeval forests and tiny animal organisms in the seas which covered parts of the Earth before and during the Age of Giant Reptiles. The heat given out by burning coal is the sunshine that was trapped by plants which were growing millions of years ago, long before men had appeared on the Earth. Fuel oils and petrol, which is obtained from oil, are used by petrol and diesel engines. Coal and oil supply heat for electricity power-stations. Electricity is used for lighting, heating and driving machinery.

Heat in the home

Heat is used for warming the home and for cooking, boiling water, washing and cleaning, ironing and drying clothes, etc. Light is provided by the white-hot filaments and fluorescent gases in electric lamps, and, occasionally, by the luminous flames of candles and gas and oil lamps.

Heat in industry

In industry heat is used for melting and moulding metals, making electricity, operating steam-engines and steam turbines, welding, making glass, central heating, etc.

Heat is energy

Heat is energy. Movement is energy. Heat energy can be changed into movement energy, and vice versa. You know that when you take violent exercise you feel warm.

Energy takes several forms, and one kind of energy can be changed into another kind. Thus, in an electric fire electrical energy is changed into heat and light energy. After several minutes of use the blade of a saw becomes warm because energy of movement, or mechanical energy, becomes heat energy. In striking a match mechanical and chemical energy are changed into heat energy. Your hands become warm if you rub them together. The end of a bicycle pump becomes warm after several minutes of pumping.

Conservation of energy

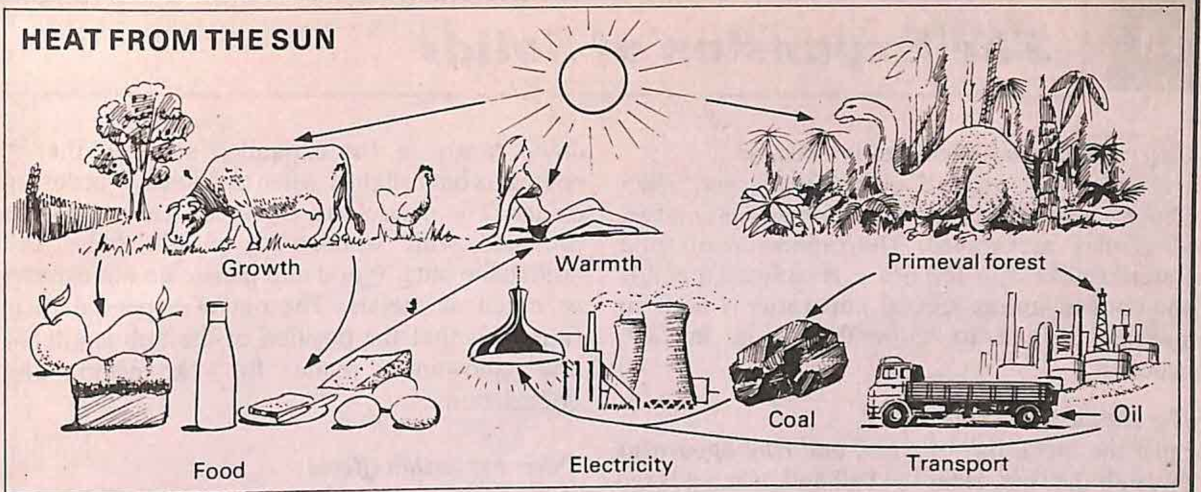
When Count Rumford was chief of the Munich Naval Arsenal, he noticed that, during the boring of a cannon, a blunt borer produced more heat than a sharp one because of greater friction. Later on, other experimenters discovered that so much work will produce only so much heat. They concluded that energy is never really used up, and, though energy can be changed from one form into another, the total amount of energy remains the same. This conclusion is known as the *Law of Conservation of Energy*.

Making heat energy

Here are three simple experiments to show how heat energy can be made from other forms of energy.

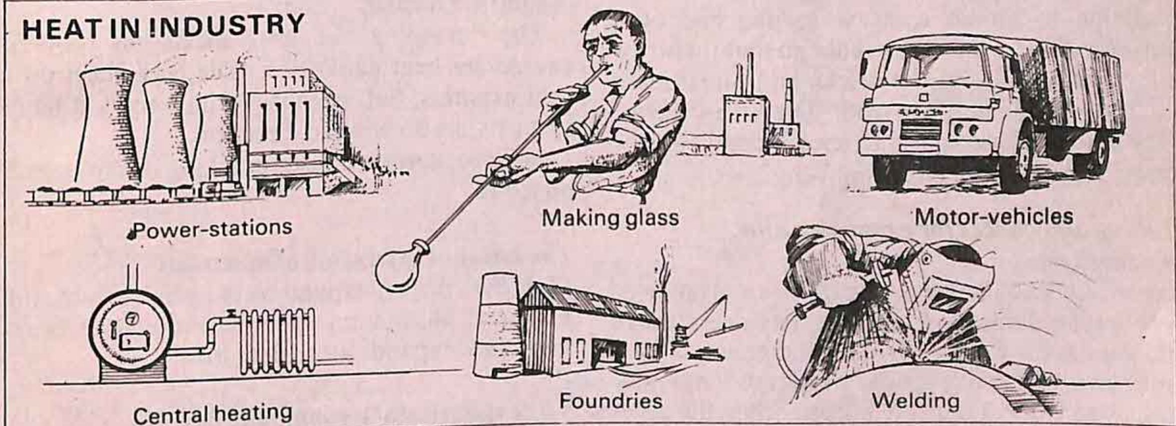
1. Vigorously rub a metal button against a piece of wood. Feel the button. It is warm. Mechanical energy has become heat energy.
2. Soak a stick of chalk in *methylated spirit* and place it on an asbestos pad. Ignite the spirit. When the spirit has burned away, carefully touch the stick of chalk. What do you notice? Chemical energy has become heat energy.
3. Use paper-clips to connect the ends of two covered copper wires to the terminal strips on a 3 V torch battery. Touch the terminals on a 3 V lamp bulb with the other ends of the copper wires. The lamp lights. Electrical energy has become heat and light energy.

HEAT FROM THE SUN

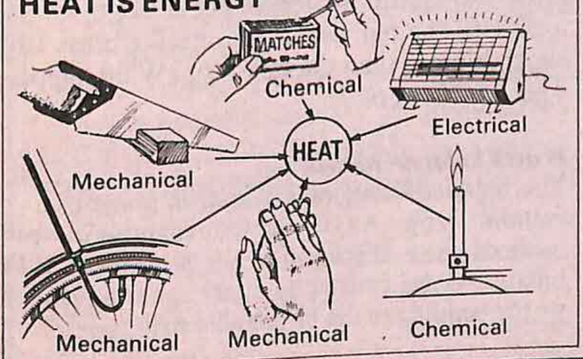


HEAT IN THE HOME

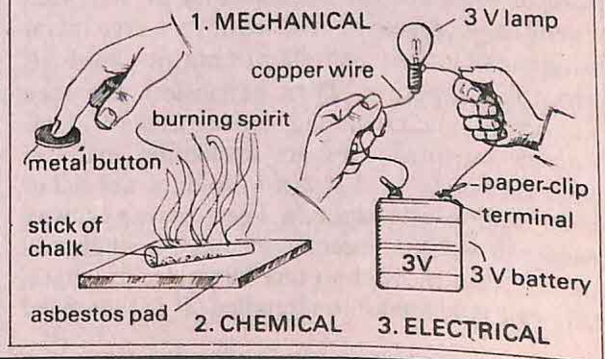
HEAT IN INDUSTRY



HEAT IS ENERGY



MAKING HEAT ENERGY



18 The Expansion of Solids

Materials expand when they are heated

Most materials *expand*, or become larger, when they are heated, and *contract*, or become smaller, when they are cooled. The expansion of solid materials, like iron and brass, is so small that it is not noticed unless special apparatus is used to measure it and to show that it is, in fact, occurring.

The expansion of solids

Push the metal ball of a *ball and ring apparatus* through the ring. Heat the ball and, when it is red hot, lift it with tongs and place it on the ring. The ball does not fall through the ring. It has expanded. What happens when the ball cools and contracts?

Heat the bar of a *bar and gauge apparatus*. Try to push the bar into the gauge. It does not fit. Allow the bar to cool. It now fits into the gauge for it has contracted in length.

Lay a thick iron rod across two bricks. Use plasticine to attach a straw to one end of a knitting needle. Place the needle, so that the straw is upright, on one of the bricks and underneath the rod. Then heat the rod. The straw turns. Why? Now allow the rod to cool. The straw now turns in the opposite direction. Why?

Making allowances for expansion and contraction

Expansion and contraction can be a nuisance or even cause damage. Therefore, engineers make allowances for expansion and contraction. Steam pipes are built with loops, bends and movable collars so that no damage is done when the pipes become hot and expand. Telephone wires and power cables are left slack so they do not snap when they contract in cold weather. Large metal bridges rest loosely on rollers or plastic pads built into their supports. Then expansion can take place freely and no damage is done to the bridges. Narrow tar-filled gaps are sometimes made in concrete roads so that cracking does not occur when the concrete expands. The rails on a railway track are welded together to make a single rail that is often more than one kilometre in length. This rail is heated and stretched. It is then fixed down firmly in the expanded state so that it contracts only slightly when the weather becomes colder. The pendulums of clocks are sometimes provided with wooden or plastic bobs and adjustable nuts. Wood and plastic do not expand as much as metals. The nut of a pendulum is turned so that the position of the bob is altered and allowance made for expansion and contraction.

Other expansion effects

It is unwise to pour hot water into a thick glass vessel. The outside of the vessel remains cool while the inside becomes hot. This results in unequal expansion of the glass and the vessel then cracks.

Heat expansion helps in the formation of deserts. Large rocks expand and crack. Then the smaller rocks so formed also expand and crack. This process is repeated until many tiny particles of sand are formed.

The "creeping" of lead sheets on roofs is caused by heat expansion. The lead sheet on a roof expands, but, because of its weight, it tends to move in a downward direction.

Heat expansion causes cracking of the enamel on teeth.

The unequal expansion of materials

Materials do not expand to the same extent. For example, aluminium expands more than brass, and brass expands more than iron.

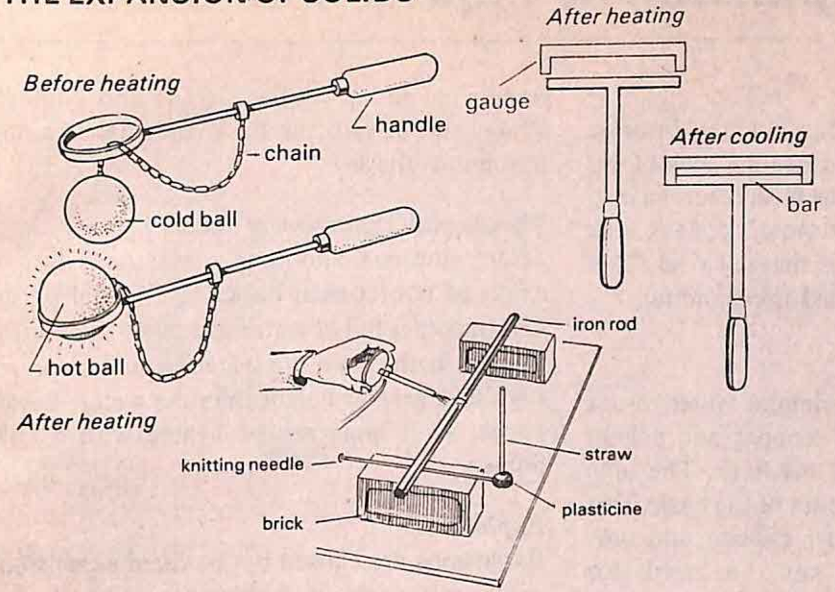
The expansion of a compound bar

Heat a *compound bar*. This consists of a strip of brass and a strip of steel of equal length riveted together. The bar bends because the brass strip expands more than the steel strip. What happens when the bar cools?

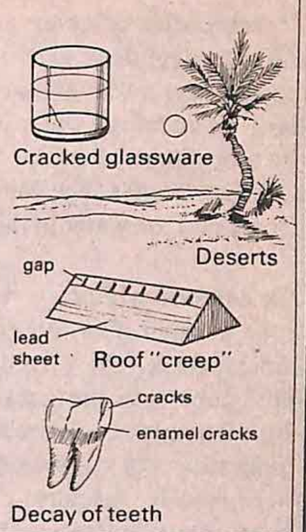
Watch balance-wheels

The balance-wheel of a watch is made of a *bi-metallic* strip. As the strip expands, it bends inwards. Any alteration in the movement of the balance-wheel caused by heat expansion is offset by the bending of the bi-metallic strip.

THE EXPANSION OF SOLIDS



SOME EXPANSION EFFECTS



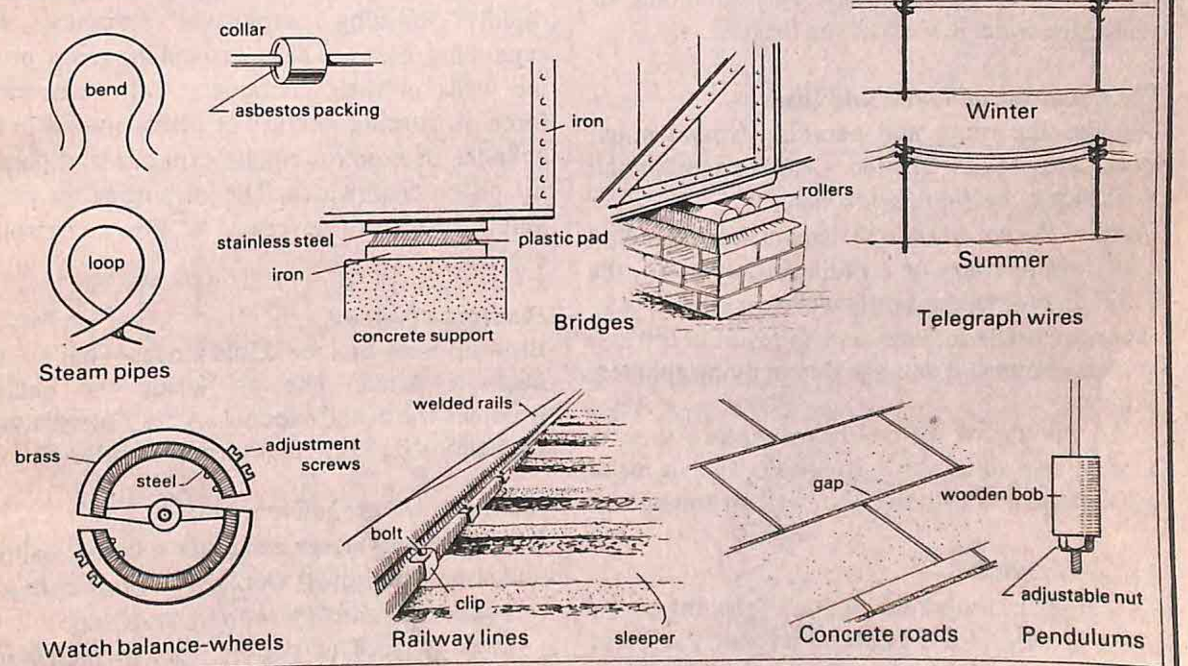
Cracked glassware

Deserts

Roof "creep"

Decay of teeth

ALLOWANCES FOR EXPANSION AND CONTRACTION



Steam pipes

Bridges

Telegraph wires

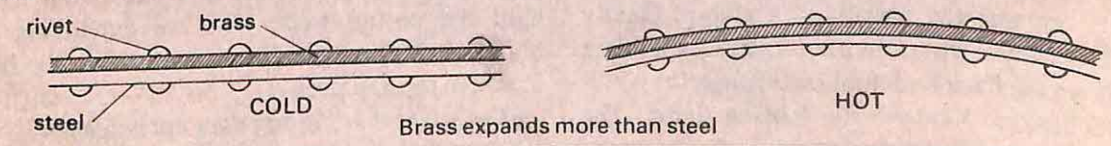
Watch balance-wheels

Railway lines

Concrete roads

Pendulums

COMPOUND BAR



Brass expands more than steel

19 The Expansion of Liquids and Gases

The expansion of water

Fill a conical flask with coloured water. Insert a stopper and a thin glass tube into the neck of the flask. Some of the water in the flask is forced into the tube. Gently heat the bottom of the flask with a bunsen burner. The water in the tube rises. This shows that the water in the flask is expanding.

The expansion of air

Pour a small quantity of coloured water into a conical flask. Fit a rubber stopper and a long glass tube into the neck of the flask. The tube should nearly touch the bottom of the flask. This apparatus is sometimes called an *air thermometer* because it can be used for measuring temperature. Hold the flask with your hand. The warmth from your hand causes the air in the flask to expand rapidly. This expanding air pushes the water in the flask up the tube.

The expansion of liquids and gases

Liquids, like water and paraffin, expand much more than solids. Heated gases expand much more than either liquids or solids.

Danger! Do *not* warm a sealed bottle by standing it in front of a fire or a radiator. If you do, the liquid and air in the bottle will expand and may cause the bottle to burst and so result in the loss of its contents and damage due to flying splinters of glass.

Do *not* throw an empty toothpaste tube or aerosol can on to a fire. If you do, the air inside will expand and so cause it to swell up and burst.

A water fountain

Fit a rubber stopper and a glass tube, the end of which is a jet, into the neck of a round flask. The jet must be inside the flask. Invert the flask. Place the lower end of the tube in a beaker of coloured water. Support the flask with a clamp. Gently warm the flask with a bunsen flame. Expanding air leaves the flask and bubbles through the water in the beaker. Remove the bunsen flame. The remaining air in the flask cools and contracts. Water rushes into the flask and makes a small fountain at the jet.

The unequal expansion of liquids

Insert stoppers and long glass tubes into the necks of two conical flasks, one full of paraffin and the other full of water. Place the two flasks in a water bath. Heat the water bath. The paraffin rises to a greater height than the water. Paraffin burns, so it must *not* be heated with a naked flame.

Explosions

Explosions are caused by the rapid expansion of gases and vapours. Explosives generally burn quite harmlessly in the open. In confined spaces, however, such as bomb and shell containers, rapidly burning explosives produce hot expanding gases. These expanding gases break the walls of their containers with tremendous force. A burning mixture of petrol and air in the cylinder of a petrol engine expands and pushes the piston downwards. The burning of the petrol and air mixture is really a slow, controlled explosion.

Bursting a balloon

Blow up a toy balloon. Hold it near—but not too near—a flame. The air inside the balloon becomes warm and expands. After a few seconds, the balloon bursts to make a small explosion.

Making a hot-air balloon

Perhaps your teacher will make a hot-air balloon and show you how it works. *You must not make this balloon because of the danger of fire.*

Soak a piece of cotton wool in methylated spirit and place it on a brick. Open a very large paper bag and hold it over the cotton wool. Then light the cotton wool. The hot expanding air above the cotton wool rises and enters the bag, and then the bag rises.

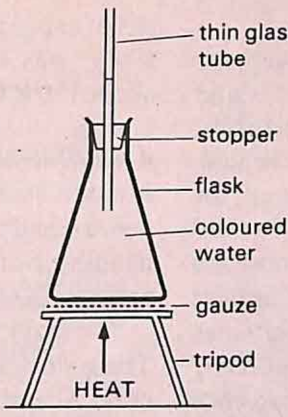
Take care that the bag does not catch fire.

DANGER!

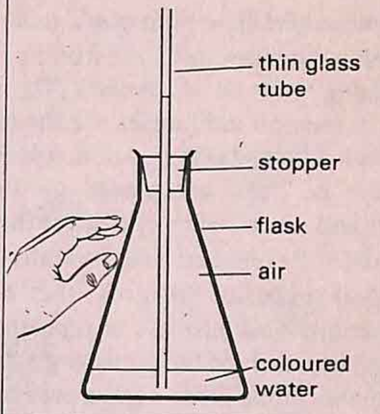
DO NOT stand a sealed bottle in front of a fire

DO NOT throw an empty toothpaste tube or aerosol can on to a fire

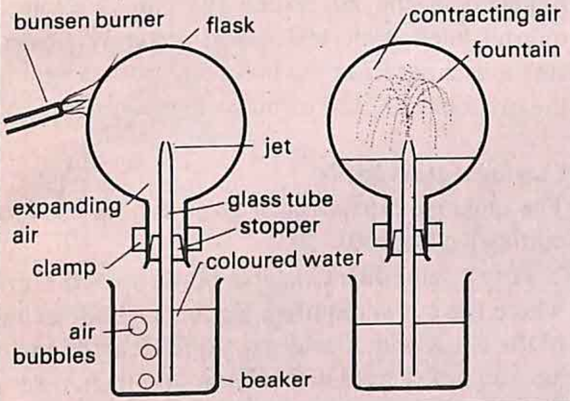
WATER EXPANDS



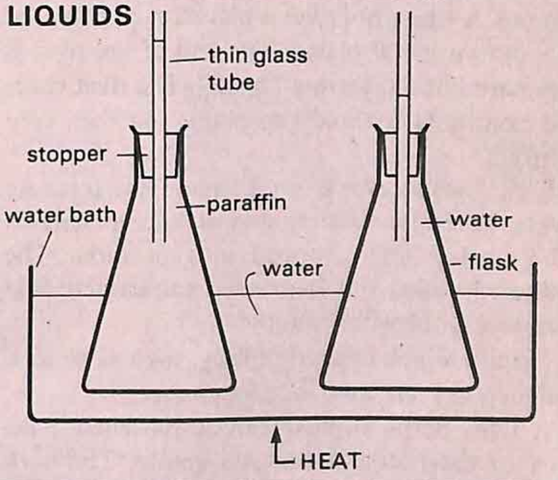
AIR THERMOMETER



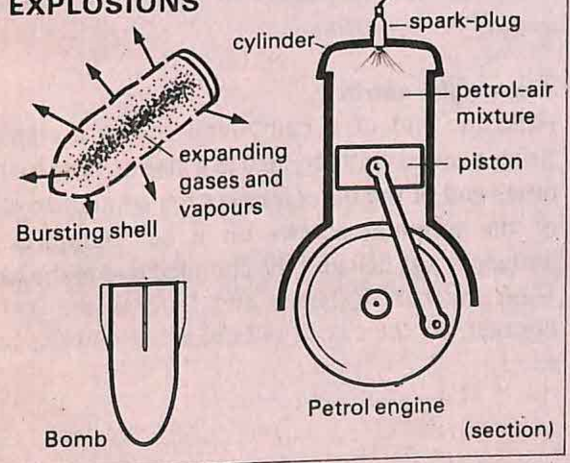
WATER FOUNTAIN



THE UNEQUAL EXPANSION OF LIQUIDS



EXPLOSIONS

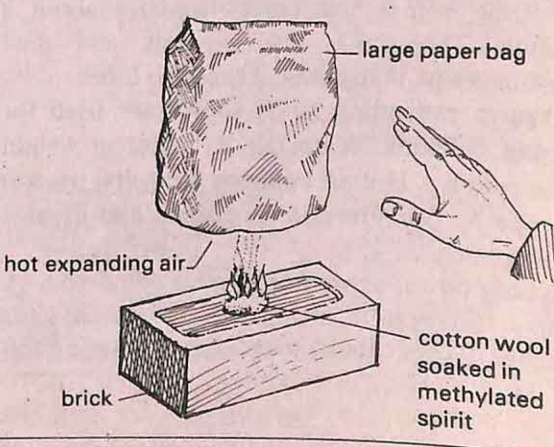


Bursting shell

Bomb

Petrol engine (section)

HOT-AIR BALLOON



20 Using Expansion

Some useful applications of expansion

Builders occasionally use iron *tie-rods* to support bulging walls in old houses. The iron "X"s and "S"s seen on old houses are the ends of tie-rods. When a tie-rod is in position, it is strongly heated. "X"s or "S"s are placed on the ends of the rod and screwed firmly against the walls. The rod cools and contracts and the walls of the house are pulled inwards towards the normal upright position. This process is repeated several times until the walls of the house are held in position by the enormous force acting between the two ends of the tie-rod.

Expansion has a very useful application in *riveting*. A white-hot rivet is placed in its prepared hole in two metal plates. The end of the rivet is hammered flat to form a "head". The rivet cools and contracts to hold the plates together very tightly.

Gun barrels were once made in separate layers. Several metal cylinders of different lengths were heated and dropped into position. The cylinders cooled and contracted and so were held in position, one within another.

Liquids which expand rapidly, such as alcohol and mercury, are used in *thermometers*.

A tight bottle stopper can be loosened if the neck of the bottle is warmed gently. The neck expands slightly and so the stopper is set free.

A rusty screw can be loosened if a hot poker or soldering iron is held on its head for about a minute. The screw first expands and then contracts and, in so doing, it becomes loose.

Warm expanding air is sometimes used for raising balloons. Warm air is lighter in weight than cold air. Hot-air balloons were first used in Europe by two Frenchmen, Joseph and Etienne Montgolfier.

Many power-station generators are driven by *steam turbines*. A steam turbine has a large number of small blades which are spun around by jets of expanding steam. A steam turbine, used as a toy, was mentioned by Hero of Alexandria about 150 B.C.

A model steam turbine

A model steam turbine can be made from a metal can, a needle, a cork, six or eight razor blades and a thin strip of tinplate, about 1 cm wide and 15 cm long. *Be careful with the razor blades!*

The razor blades are placed in slots in the cork. These slots are cut at an angle to the length of the cork. A needle is pushed through the centre of the cork. The tinplate strip is bent at right angles and soldered to the side of the can. Dents, which support the turbine wheel, are made in the lid of the can and the tinplate strip. Two small holes are punched in the lid. When the can is about a quarter-filled with water and strongly heated, steam escapes from the holes and pushes against the razor blades. The turbine wheel turns rapidly.

Cutting a glass bottle

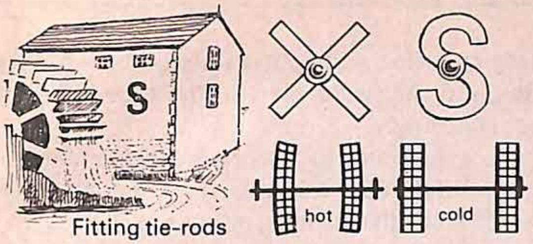
The unequal expansion of glass can be used for cutting a glass bottle.

Pour engine oil into a large bottle up to the level where the cut is required. Cover the bottom half of the bottle with a cold wet cloth. Heat the end of an iron poker until it is red-hot and then lower it into the oil. The bottle cracks evenly at the oil level. *Your teacher should do this for you because it could be dangerous.*

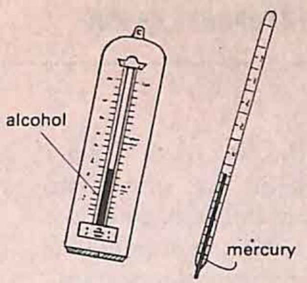
A model fire alarm

Hold the end of a compound bar in a clamp. Bring a metal contact, held in a clamp, near to the other end of the bar. Connect the contact to one of the terminal screws on a bell. Connect a battery to the bell and the clamped end of the bar. Heat the bar. It bends and touches the metal contact, so the circuit is completed and the bell rings.

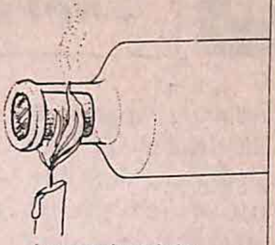
USING EXPANSION



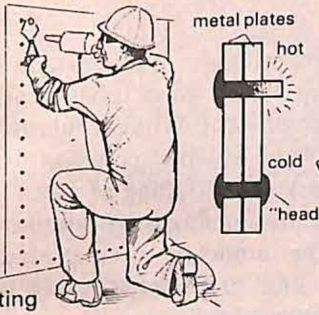
Fitting tie-rods



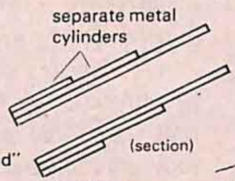
Thermometers



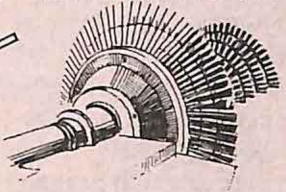
Loosening tight bottle stoppers



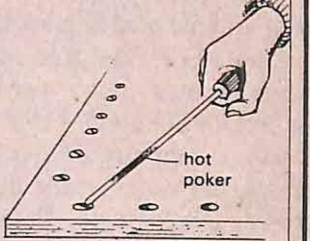
Riveting



Making gun barrels


The cover has been removed to show the blades

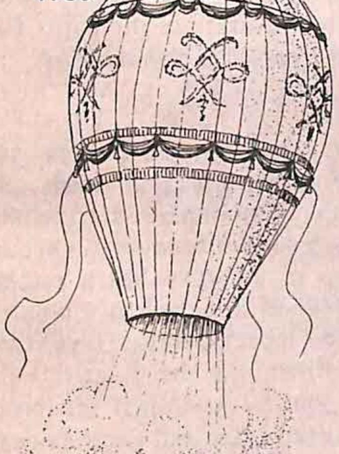
Steam turbines



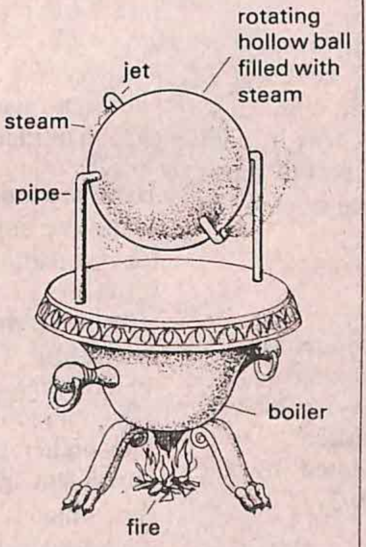
Loosening rusty screws

MONTGOLFIERS' HOT-AIR BALLOON

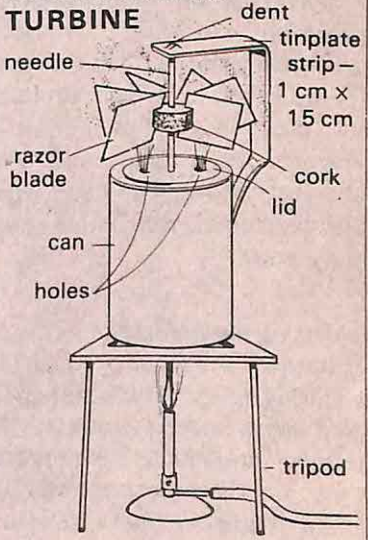
Used about 1780



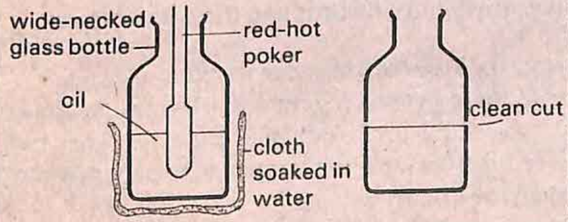
HERO'S ENGINE



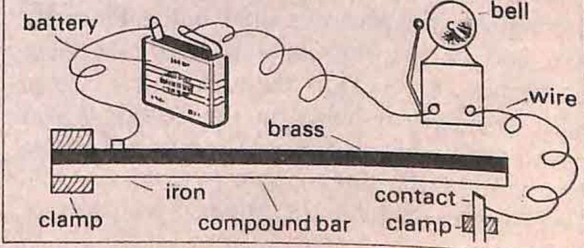
MODEL STEAM TURBINE



CUTTING A GLASS BOTTLE



MODEL FIRE ALARM



21 Thermometers

Heat and temperature

"The water in this kettle is at a higher temperature than the water in that one." This statement tells you that the water in one kettle is hotter than the water in the other. It does not tell you just how much hotness these kettles contain.

Many people make the mistake of thinking that heat and *temperature* are the same thing, but they are not. For example, a teaspoonful of boiling water is at a much higher temperature than a bucket of cold water; but if two teaspoonfuls of boiling water are poured into a bucket of cold water, the water in the bucket is still at a much lower temperature than boiling water even though it contains at least twice as much heat as one teaspoonful of boiling water.

The senses are unreliable temperature indicators

Place one hand in a dish containing warm water and the other in a dish containing cold water. Now place both hands in a dish containing lukewarm water. The hand which was in cold water feels warm. The hand which was in warm water feels cool. But both hands are now in the same water!

Measuring temperature

It is because the sense of touch is so unreliable for measuring temperature that special instruments, called *thermometers,* are used. "Thermo" means "hotness" and "meter" means "measure".

An air thermometer was invented by the Italian scientist Galileo Galilei in 1593.

Making an air thermometer

Insert a stopper and a thin glass tube, about 30 cm long, into the neck of a small bottle. Place the open end of the tube in a beaker containing coloured water. Support the tube with a clamp. Place your warm hand on the bottle. Warm expanding air is forced out of the bottle. Remove your hand, and the remaining air contracts and water rises up the tube. Variations in temperature cause expansion and contraction of the air in the bottle, and the water level in the tube falls and rises accordingly.

Notice the water level when the thermometer is placed in different positions—in a shaded place, in a cold wind, in sunshine, near a fire, etc.

Thermometers

Classroom, greenhouse and laboratory thermometers are sealed glass tubes containing either *mercury* or *alcohol.* When a thermometer is warmed, the fluid which it contains expands and rises. The rising and falling of these liquids indicates temperature changes. A common type of classroom thermometer is supported in a wooden frame, and the delicate glass bulb is protected by a metal shield.

A model thermometer

Insert a thin glass tube and a rubber stopper into the neck of a small bottle full of *carbon tetrachloride*. Place the bottle in a water bath, and then raise the temperature of the bath. The carbon tetrachloride rises in the glass tube.

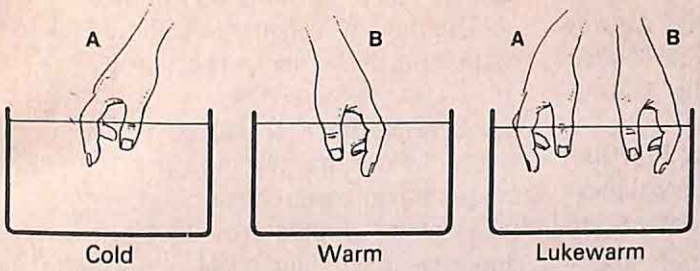
Metal thermometers

Metal thermometers, called *pyrometers,* are used for measuring the temperatures in ovens and furnaces. In a metal thermometer, a bimetallic strip bends as it becomes hot because of unequal expansion. The top of the strip has a ratchet which turns a cog-wheel attached to a pointer. This pointer indicates the temperature on a scale. The higher the temperature, the greater is the movement of the pointer. A simpler version of this, which is often used in gas and electric ovens, consists of a long bimetallic strip in the form of a coil. A pointer is attached to the end of the strip at the centre of the coil. When the coil becomes hot, the strip bends inwards and the pointer turns.

How an oven thermometer works

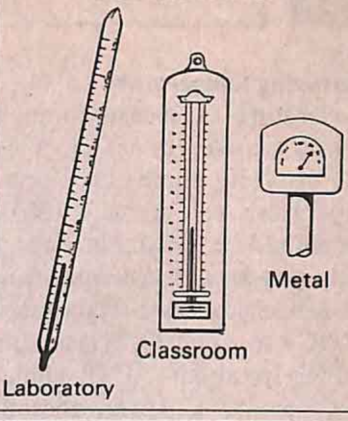
Use pliers to twist together two long wires, one of copper and one of iron. Heat the wires. They twist and turn because the copper wire expands more than the iron wire.

THE SENSES ARE UNRELIABLE TEMPERATURE INDICATORS

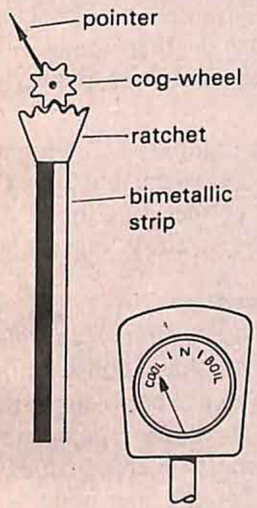


Hand A feels warm in lukewarm water; hand B feels cool

THERMOMETERS



METAL THERMOMETER

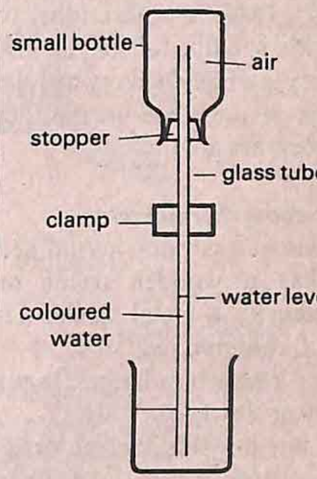


GALILEO GALILEI

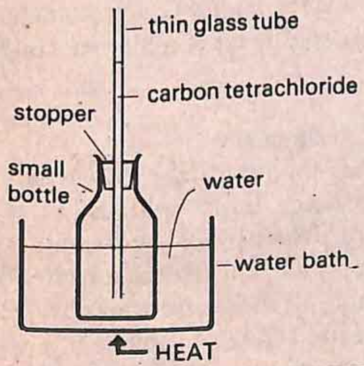
1564-1642

Inventor of the air thermometer

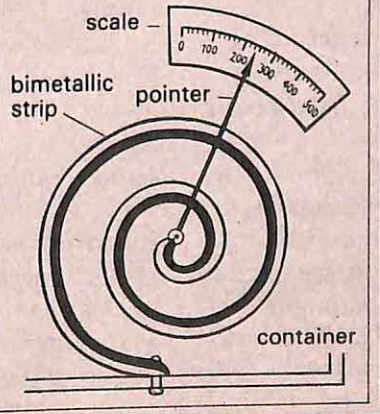
AIR THERMOMETER



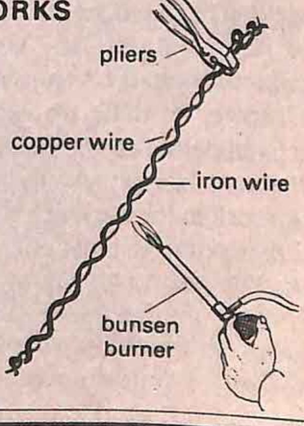
MODEL THERMOMETER



OVEN THERMOMETER



HOW AN OVEN THERMOMETER WORKS



22 Measuring Temperature

Measuring temperature

Temperature is measured in *degrees Celsius* (°C). Water freezes at 0°C and boils at 100°C, and between these two points the Celsius temperature scale contains 100 degrees.

It should be noted that, according to function, different types of thermometers use different parts of the Celsius scale—laboratory thermometer, −10°C to 110°C, classroom thermometer, −10°C to about 55°C, clinical thermometer, 35°C to 42°C, oven thermometer, 0°C to 600°C, etc.

A laboratory thermometer

Examine a laboratory thermometer.

It is a long thin glass tube, sealed at one end and with a bulb, full of *mercury,* at the other. Mercury is a liquid silvery metal.

Look at the scale on the thermometer. How many degrees are there?

A classroom thermometer

Examine a classroom thermometer.

It has a wooden frame and the bulb is protected by a metal shield. The bulb contains *alcohol,* coloured red.

Place it near a radiator. Does the spirit expand quickly or slowly?

Do *not* put this thermometer into hot water, because its scale does not go beyond about 55°C. Its scale does go below 0°C, the freezing-point of water.

Checking the fixed points

The temperatures at which water always becomes steam or ice (providing the atmospheric pressure is normal) are called the *fixed points.* The fixed points can be checked.

Insert a laboratory thermometer into a two-holed cork in the neck of a flask containing water. The thermometer must not touch the water in the flask. The second hole is an outlet for steam. Boil the water in the flask. If the thermometer is accurate, the mercury will rise to the 100° mark.

Support a funnel containing crushed ice in a beaker. Place the same thermometer, when it is cool, in this ice. The mercury should fall to the 0° mark if the thermometer is accurate.

Some temperature measurements

Use a laboratory thermometer to make these temperature measurements:

(a) Take the temperatures of a greenhouse, a shed and the open air. Which has the highest temperature? Make these measurements on different days—cold, dull, sunny, windy, etc.

(b) Take soil temperatures, at a depth of about 10 cm, each day for a few weeks in spring. Compare these with air temperatures taken at the same time. Do not push the thermometer into the soil, or it will be damaged. Use a stick to make a hole in the soil first.

(c) On the same day, compare soil temperatures at depths of 5 cm, 10 cm, 15 cm and 20 cm.

(d) Compare the soil temperature in the shade of a tree with that in the open air. Which is higher?

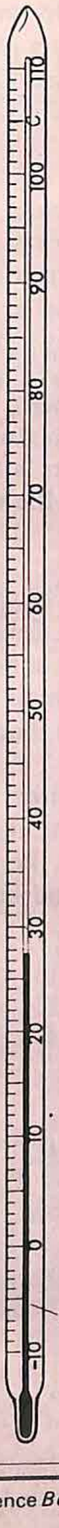
Measuring body temperature

Doctors and nurses use a *clinical thermometer.* This type of thermometer has a constriction in the part of the glass stem that is between the bulb and the scale; and so, when the temperature of a person's body is taken, the mercury does not fall back into the bulb when the instrument is moved from his warm mouth into the cool air in the atmosphere, and the thermometer shows the temperature as it is in the person's mouth. Vigorous shaking causes the mercury to fall back through the constriction. This thermometer must be cleaned with a warm, not hot, antiseptic fluid. The normal temperature of the human body is 36.9°C.

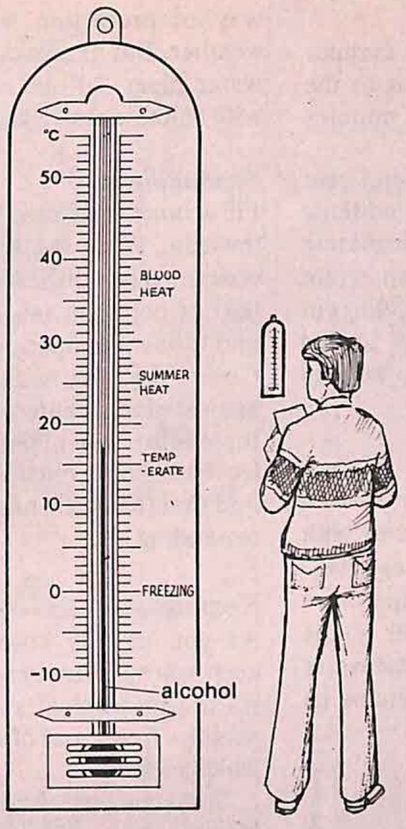
Using a clinical thermometer

Place a clinical thermometer in your own mouth. Remove it after about thirty seconds. What is your temperature? Then shake the thermometer so that the mercury falls below the constriction. Make sure that it is clean for someone else to use by washing it in a mild antiseptic fluid.

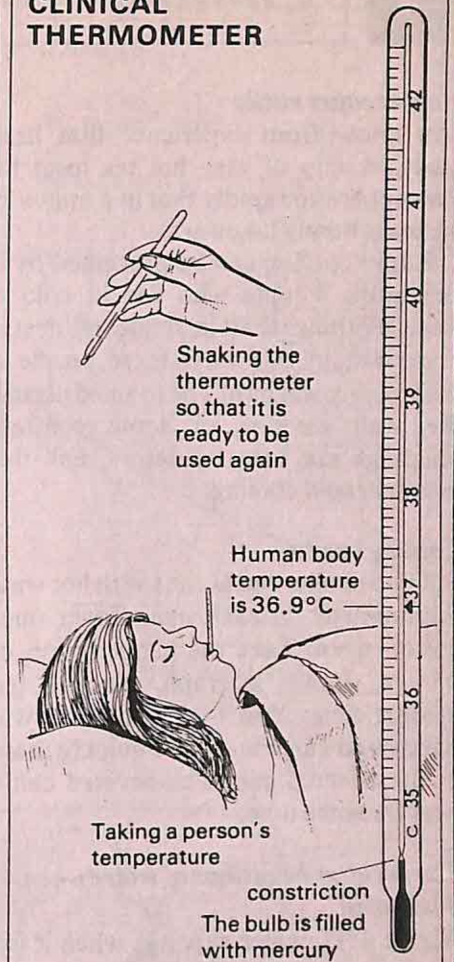
LABORATORY THERMOMETER



CLASSROOM THERMOMETER



CLINICAL THERMOMETER


42
41
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37
36
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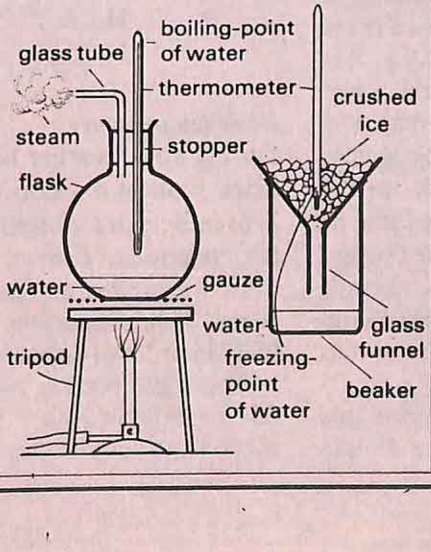
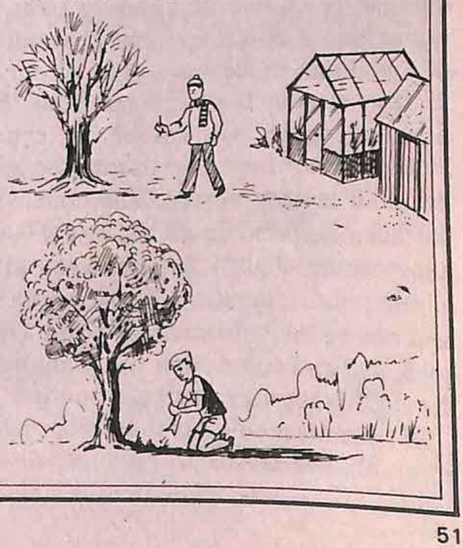
C
Shaking the thermometer so that it is ready to be used again
Human body temperature is 36.9°C
Taking a person's temperature
constriction
The bulb is filled with mercury

CHECKING THE FIXED POINTS



TEMPERATURE MEASUREMENTS



23 Cooling

Heat escapes easily

You know from experience that heat escapes easily. A cup of very hot tea loses heat to the atmosphere so rapidly that in a matter of minutes the tea is barely lukewarm.

Rapid cooling can be prevented by using heat insulators. People who live in cold conditions wear clothing that is made of heat insulating materials; in this way, these people can retain their bodily warmth. The foamed plastic fillings in the wall cavities of some centrally heated buildings are heat insulators, and they help to prevent rapid cooling.

Cooling curves

Fill two similar metal cans with hot water. Place a thermometer in each can. Cover one can with cotton wool. Take the temperatures every half-minute. Draw a graph, plotting temperature against time. You notice that the water in the uncovered can cools more quickly than the water in the covered can. The covered can retains its heat for some time.

The peculiar behaviour of water when it is cooled

Above 4°C, water expands when it is heated, in the same way as other liquids. However, below 4°C, water expands when it is cooled. Water expands when it freezes. When water changes into ice, its volume increases by 10%. Ice, then, is not as heavy as water. 1 cm^3 of water has a mass of 1 g; 1 cm^3 of ice has a mass of only 0.9 g. It is for this reason that icebergs float. Burst water pipes in winter are caused by expanding ice. Ponds do not freeze up during the winter unless the cold is very severe. The cold water on the surface of a pond floats because it is not quite as heavy as the slightly warmer water at the bottom of the pond. Therefore, ice forms on the surface and not on the bottom of the pond. During a cold spell, fish and some other water animals retreat to the slightly warmer depths of ponds.

How remarkable it is that water behaves in this way! Nature seems to have provided a simple way of protecting water animals during cold weather. But nature does not protect any outside water pipes, so make sure they are well *lagged* with suitable materials.

Expanding ice

Fill a small unwanted bottle with water. Screw on the cap. Place the bottle in a freezing mixture contained in a dish. A freezing mixture contains 1 part of common salt and 2 parts of crushed ice, and it has a temperature that is lower than 0°C. Cover the dish with a cloth as a protection against glass splinters. If the weather is very cold, there is no need to use a freezing mixture; simply leave the bottle outside. Some hours later you will find that the bottle has burst under the pressure of expanding ice.

Keeping cool

As you already know, men and animals must keep warm. However, they must not become too warm. In tropical countries animals and men perspire freely and often find some shaded spot in which to lie.

Some normal body temperatures are given below. Any extreme deviation from these temperatures would cause death. Persons with temperatures lower than 36°C and higher than 38°C are usually ill.

Man ..	36.9°C
Horse ..	37.8°C
Dog ..	38.3°C

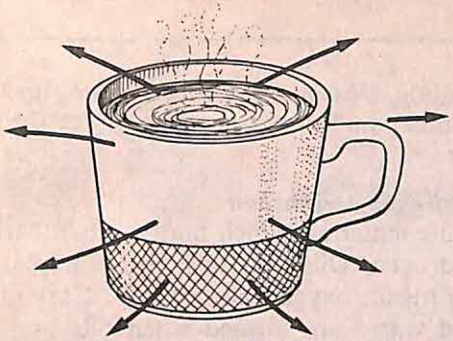
Body temperature

During cold weather bodily heat is provided by extra food and vigorous exercise. This heat is kept in by extra clothing and the skin, which is a poor conductor of heat.

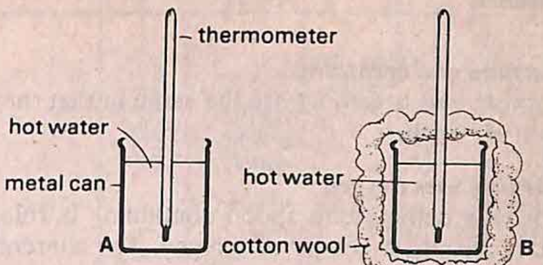
In warm weather perspiration forms on skin pores. This evaporates and takes heat from the body in order to do so.

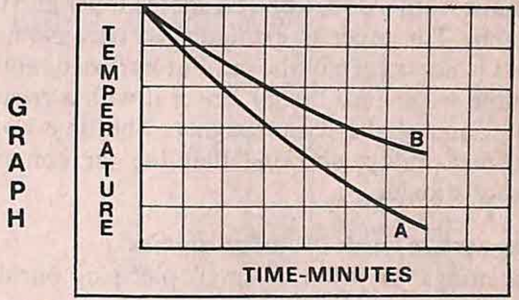
Too rapid cooling causes chills. Therefore, do not sit about in your P.E. clothing after you have taken vigorous exercise.

HEAT ESCAPES EASILY

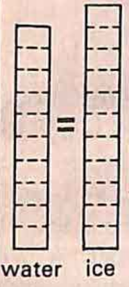


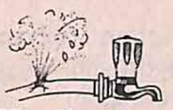
COOLING CURVES





THE PECULIAR BEHAVIOUR OF WATER

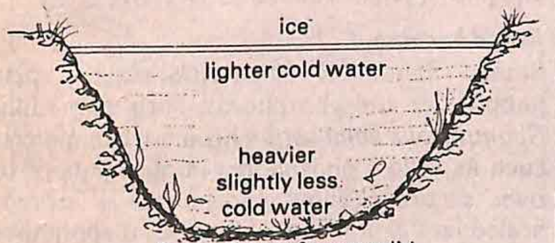




Above 4°C, water contracts on cooling. Below 4°C, it expands on cooling

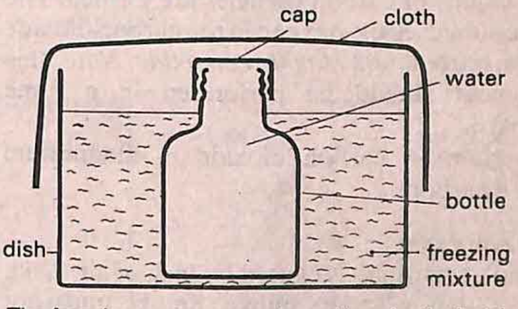
Burst water pipes

Icebergs float



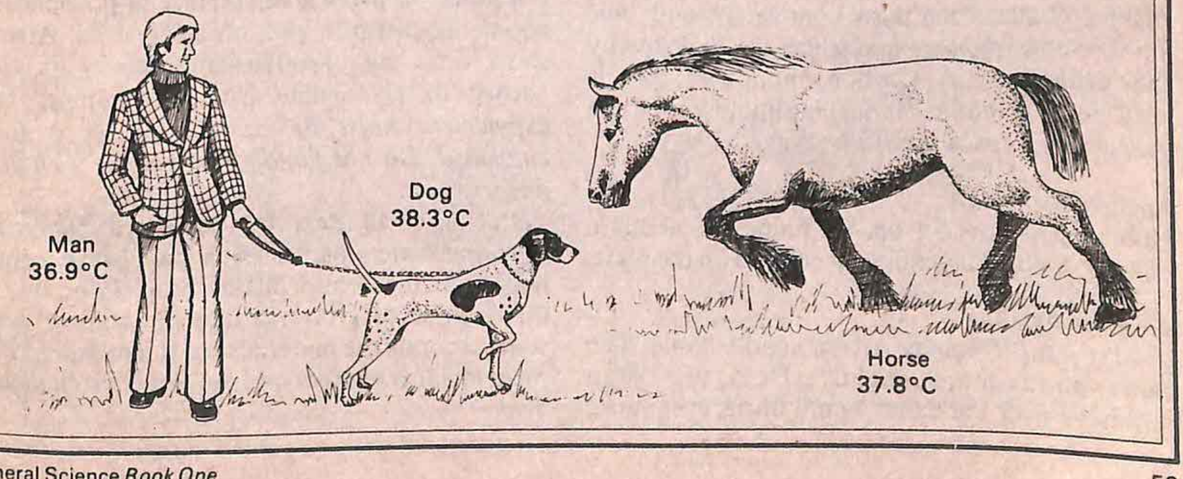
Ponds do not freeze solid

EXPANDING ICE



The freezing water expands and breaks the bottle

ANIMAL TEMPERATURES



24 Burning

Burning and breathing

Burning and breathing are the same in that they both use oxygen.

Burning uses oxygen

Lower a deflagrating spoon containing burning charcoal into a gas-jar of oxygen. The charcoal burns rapidly. Charcoal is a form of carbon that is made from wood. Lower a lighted taper into the gas-jar. The taper is extinguished because now there is no oxygen in the jar. Put a small quantity of lime-water into the jar, cover it with a grease-plate, and shake it thoroughly. The lime-water becomes milky, showing that the jar contains carbon dioxide.

Magnesium burns in carbon dioxide

Use tongs to lower a small piece of burning magnesium into a gas-jar containing carbon dioxide. The magnesium continues to burn and black clouds of carbon particles are formed. The magnesium uses the oxygen in the carbon dioxide to form carbon and *magnesium oxide. Note:* this experiment should be performed in a fume cupboard.

Magnesium + carbon dioxide = magnesium oxide + carbon

Smoke and soot

Incomplete burning is caused by lack of air. Lack of air causes a fire to smoke. Smoke and soot consist of unburnt carbon particles.

If the petrol and air mixture in the cylinders of a motor-car engine does not contain enough air, the petrol does not burn completely and blue smoke and *carbon monoxide* gas are given out by the exhaust pipe. Carbon monoxide gas is *poisonous*. A motor-car engine should *not* be run in a confined space such as a garage.

Soot from a candle

Hold a plate over a candle flame for about a minute. A black layer of soot collects on the plate.

Air helps burning

Hold a lamp chimney over a candle flame. The flame burns more brightly. Hold two lamp chimneys over the flame, and it burns even more brightly. Warm expanding air rises up the lamp chimney and draws in more air for the flame to use.

Hydrogen and carbon

Some materials which burn contain carbon and hydrogen. Oils and fats, for example, contain hydrogen, oxygen and carbon. Carbon dioxide and water are formed when oils and fats are burned.

Carbon + oxygen = carbon dioxide
Hydrogen + oxygen = water (hydrogen monoxide)

Burning a candle

Hold a beaker above a candle flame for about a minute. Then hold a lighted taper inside the beaker. It is extinguished because the air in the beaker contains very little oxygen and much carbon dioxide. Test for water on the inside of the beaker with blue *cobalt chloride* paper. As you know, cobalt chloride paper is blue when it is dry and pink when it is moist.

Rapid burning

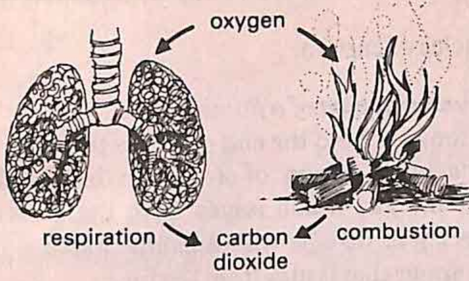
Some flammable materials, like petrol, gunpowder and phosphorus, burn very rapidly. *Spontaneous combustion* occurs when materials, such as yellow phosphorus in air, ignite of their own accord. Yellow phosphorus is stored in sealed jars containing water so that spontaneous burning cannot occur.

Spontaneous combustion

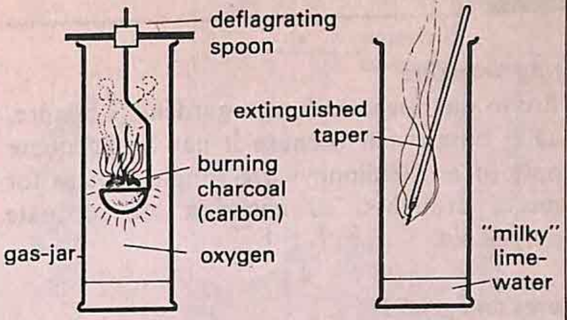
Use tongs to place a small piece of phosphorus, about the size of a pea, on a metal lid. After a short time the phosphorus burns of its own accord to give white clouds of fumes. *This experiment must be carried out in a fume cupboard. Do not handle phosphorus with your fingers.*

Put a small heap of powdered *potassium permanganate* on an asbestos pad. Make a small hollow in the centre of this heap. Pour two or three drops of glycerine into the hollow. After some seconds the materials burst into flame. *This experiment is best carried out in a fume cupboard also.*

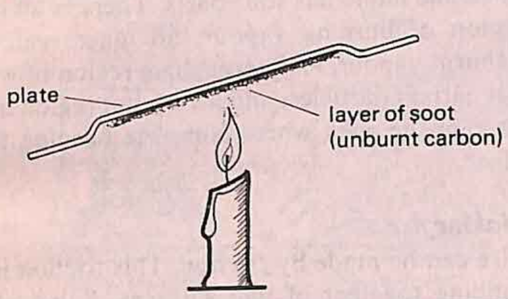
BURNING AND BREATHING



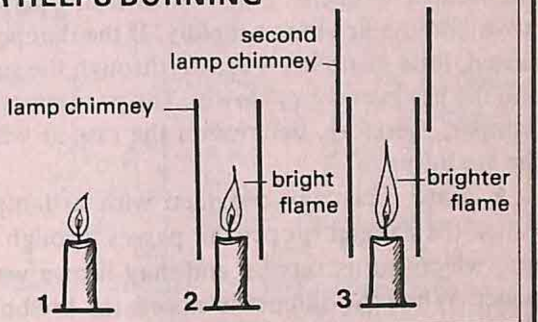
BURNING USES OXYGEN



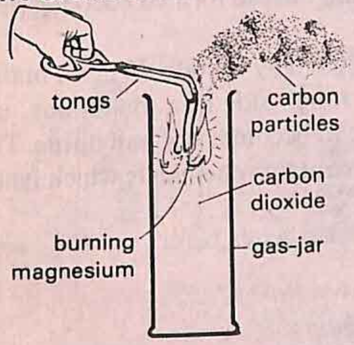
SOOT FROM A CANDLE



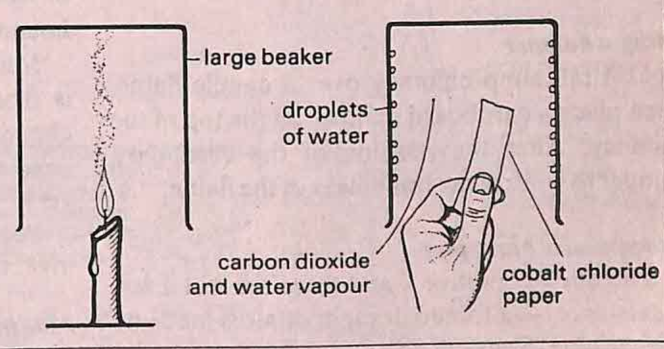
AIR HELPS BURNING



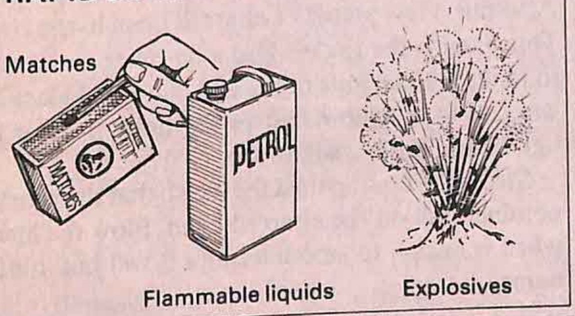
MAGNESIUM BURNS IN CARBON DIOXIDE



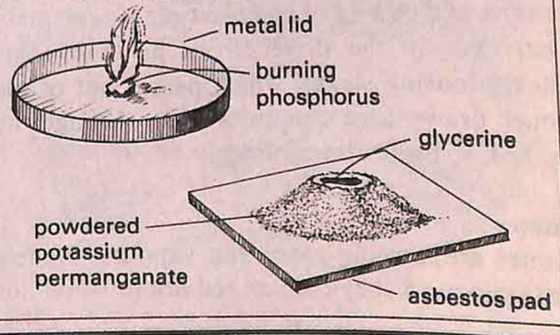
BURNING A CANDLE



RAPID BURNING



SPONTANEOUS COMBUSTION



25 Fires and Flames

Using draughts

A fire in the open, such as a gardener's bonfire, usually burns well because it has an adequate supply of air. Chimneys are simple devices for creating draughts, so ensuring an adequate supply of air.

Stoves and grates

A solid-fuel stove is provided with a *damper*. If the damper is opened, air is drawn through the stove and the fire burns rapidly. If the damper is closed, little or no air is drawn through the stove and the fire burns very slowly. The position of the damper, therefore, determines the rate at which the fire burns.

A grate is usually provided with a damper. When the damper is open, air passes through the fire, which burns rapidly and may heat a water boiler. When the damper is closed, the fire burns slowly and the heat is given out to the room instead of escaping with the hot gases and vapours that rise up the chimney.

Using a damper

Hold a tall lamp chimney over a candle flame. Then place a cardboard damper on the top of the chimney. Alter the position of the cardboard damper to control the brightness of the flame.

A locomotive blast-pipe

In a steam locomotive—and there are still a few in existence!—a forced draught of air is made by a *blast-pipe*. Some of the steam from the boiler escapes through an exhaust blast-pipe. The opening and closing of this blast-pipe is remotely controlled by the driver from his cab. This quickly moving steam, which passes out of the funnel, draws large quantities of air through the fire-box, so the fire burns fiercely.

Flames

Flames are burning gases and vapours. Flames are luminous if they contain red-hot or white-hot particles of carbon.

The unburnt part of a flame

Use tongs to hold the end of a very thin glass tube in the inner region of a bunsen burner flame. Light the gas which issues from the glass tube. Then try to do this with a candle flame, lighting the vapour that issues from the tube.

A candle flame

A candle flame has four parts. There is an outer region of burning vapour, an inner region of unburnt vapour, an intermediate region of white-hot carbon particles, and a very hot region at the base of the wick where complete burning takes place.

Making fire

Fire can be made by *friction*. This friction is the rubbing together of two surfaces. Some of the people living on the islands in the Pacific Ocean make fire by rubbing a stick in a groove in a block of wood. The wood dust so formed becomes very hot and ignites.

Matches are ignited by friction. When a match is struck on the rough side of a match-box, the chemical in its head becomes hot and burns. The head of a match contains chemicals which ignite very easily.

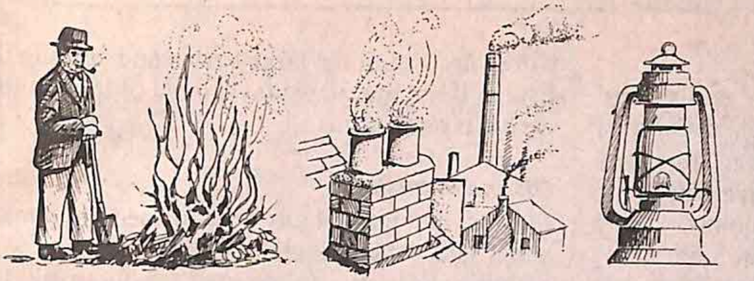
People used tinder-boxes before matches were invented.

Making a tinder-box

Make a tinder-box. Put a short piece of an old smooth file in a small flat box with a hinged lid. Also put a few pieces of charred linen in the box. This linen is the tinder. Use a hammer and a nail to make a small hole in the end of a small piece of wood. Put a lighter flint in the hole. It must fit tightly and project slightly.

Strike the flint against the file so that the sparks obtained fall on the charred linen. Blow the linen when it begins to smoulder and it will burst into flame.

USING DRAUGHTS

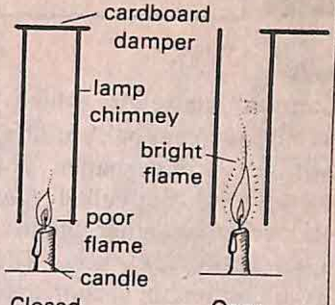


Gardeners' bonfires

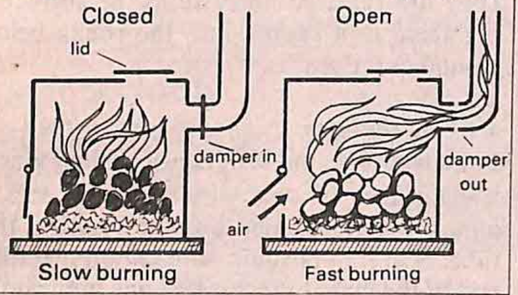
Chimneys

Hurricane lamps

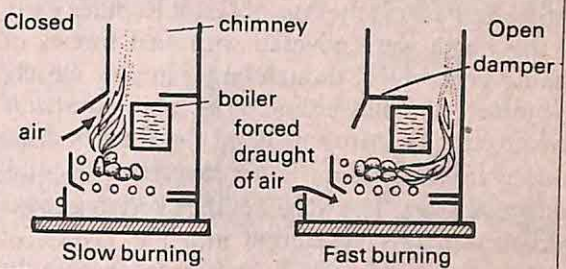
USING A DAMPER



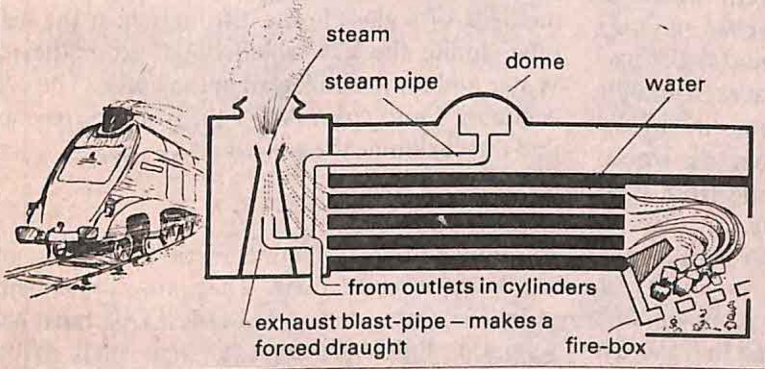
STOVE



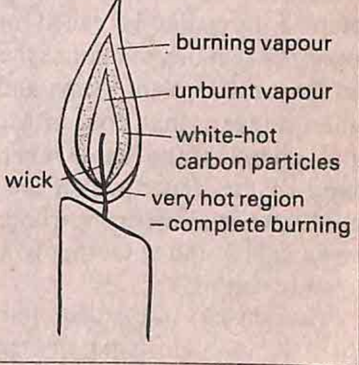
GRATE



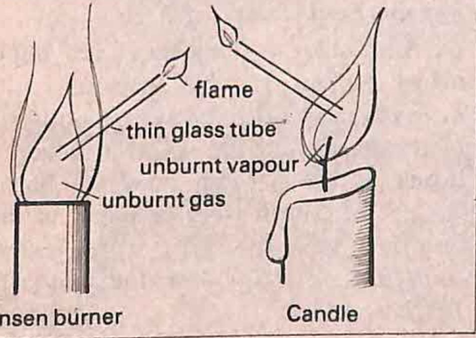
LOCOMOTIVE BLAST-PIPE


(section)
steam
dome
steam pipe
water
from outlets in cylinders
exhaust blast-pipe – makes a forced draught
fire-box

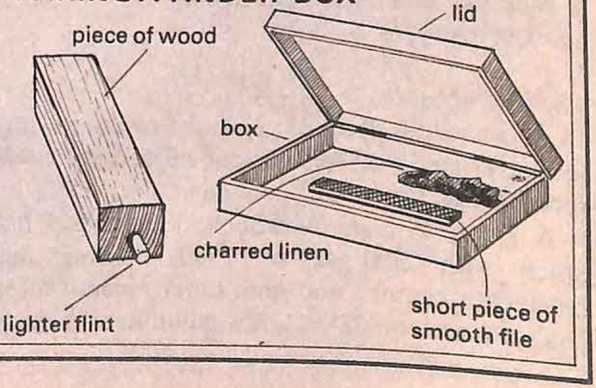
CANDLE FLAME


burning vapour
unburnt vapour
white-hot carbon particles
wick
very hot region – complete burning

THE UNBURNT PART OF A FLAME



MAKING A TINDER-BOX



26 Fuels

Fuels

Common materials which burn easily and usefully, such as coal, paraffin, petrol, methylated spirit, oil, wood, paper, coke, peat, fats and natural gas, are called *fuels*. Most fuels are obtained from either plants or animals. Living things contain carbon. Therefore, commonly used fuels contain carbon and will burn in oxygen to give carbon dioxide.

Coal is wood

Before and during the Age of Giant Reptiles parts of the Earth were covered with vast forests of giant plants which, though larger in size, closely resembled the flowerless *ferns* and *horsetails* growing today. Movements in the Earth's crust caused this vegetation to be covered with mud, sand and rocks. The weight of the overlying rocks compressed this vegetation into flat layers, or *seams*, of coal. Here and there, because of faults in the Earth's crust, coal seams appear at the surface. These provide *outcrop coal*, which is obtained by what is called *open-cast mining*. Fossilized remains of animal shells and skeletons, and imprints of plant stems and leaves, found in mines, suggest that coal is vegetable in origin. Coal contains the same chemicals as wood. Many of the things which are made from coal could also be made from wood. *Lignite*, the soft brown coal found in Germany and Australia, has a woody texture.

Peat consists of the dead moss and bog plants which accumulate in marshy regions. In Ireland it is commonly used for heating and cooking, but it is first cut into blocks with a spade and then stacked to dry.

The uses of coal

Coal is used on domestic fires, for steam-raising in power-stations, for iron smelting and, until recent times, for making coal-gas.

A Scot, William Murdoch, illuminated his office with coal-gas in 1792. During the nineteenth century and until fairly recent times, coal-gas was made in large quantities by gas-works in most of the large towns and cities in the British Isles, but, nowadays, most of the gas that we use is natural gas.

Oil and natural gas

Both oil and natural gas were formed, millions of years ago, when plants and small animals were compressed by the weight of overlying rocks. The oil and gas were trapped in cavities between the rocks or occupied the tiny holes in porous rocks. They are released and rise to the surface when engineers drill deeply into the rocks below the ground or the sea.

Making coal-gas

Fill a test-tube, made of heat-resistant glass, with small pieces of coal. Insert a glass tube, bent almost at a right angle, into the mouth of the test-tube. Seal it in position with clay. Push the other end of the glass tube through one of the holes in a two-holed stopper. Insert a short glass tube into the other hole in the stopper. Fit the stopper into the neck of a glass bottle. Strongly heat the test-tube. Ignite the gas which issues from the jet. Water and tar are collected in the bottle. The coal is changed into *coke*. Allow the test-tube to cool, and then examine the coke.

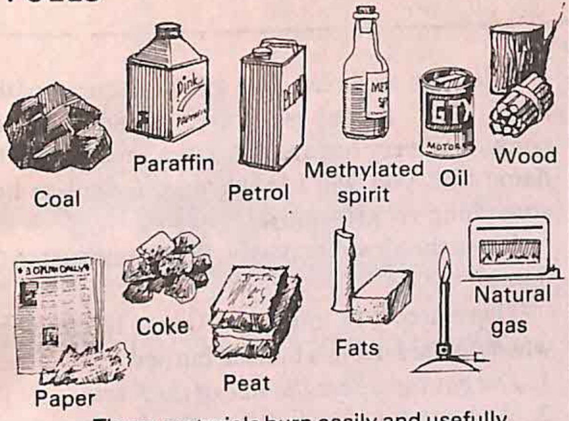
Liquid fuels

Paraffin, petrol, turpentine, methylated spirit and alcohol are liquid fuels. They are conveniently stored in tanks, cans and bottles. Oils burn with luminous flames because of their high carbon content.

Burning liquid fuels

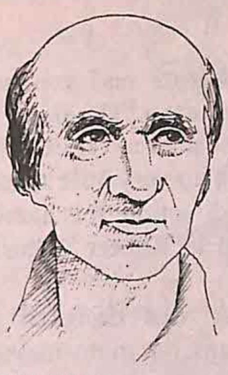
Burn, in turn, on a metal lid, a few small drops of petrol, *benzine*, paraffin, turpentine, alcohol and methylated spirit. In each case notice the colour of the flame and the speed at which the liquid burns. If the paraffin does not burn, place a "wick" of cotton wool or paper in the paraffin and then ignite this. *This experiment should not be performed except under the supervision of your teacher.*

FUELS



These materials burn easily and usefully

WILLIAM MURDOCH

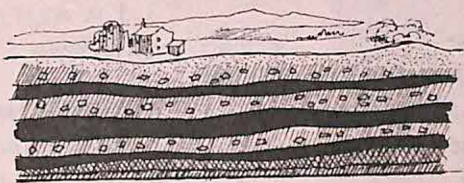


1754-1839

COAL MINING

COAL IS WOOD

A forest of long ago



Coal seams

Fossil shell

Fern imprint

Peat

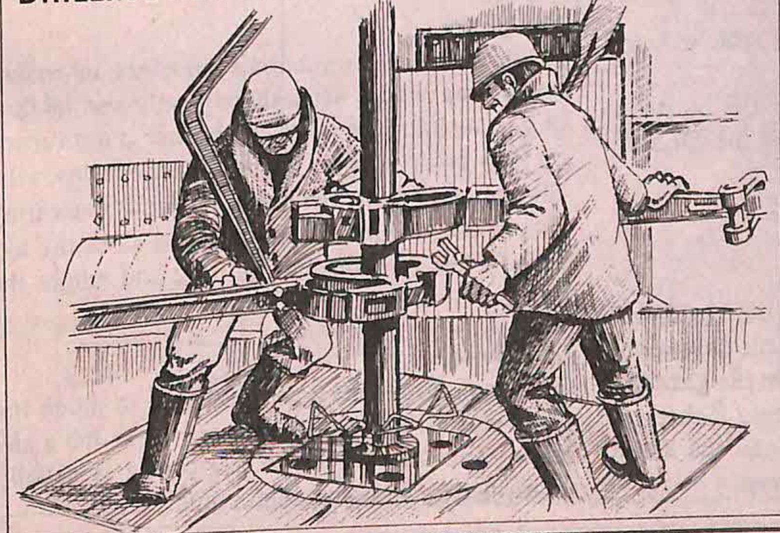
Fossil tree trunk

Lignite

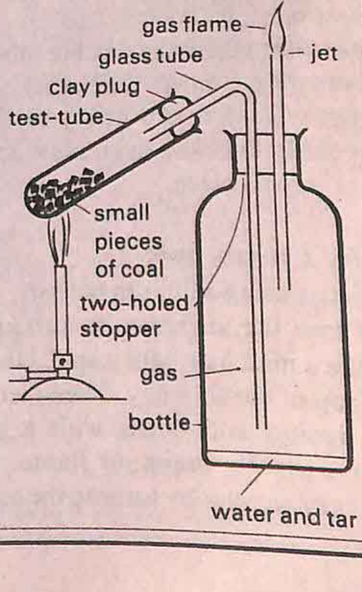
CARBON

All living things contain carbon

DRILLING FOR OIL AND NATURAL GAS



MAKING COAL-GAS



27 The Bunsen Burner

The bunsen burner

You have used a bunsen burner and you will know that it is a very handy heater. The size and the hotness of its flame can be altered very easily; it is cheap and clean; it takes up very little space; its flame can be used in any direction. It is named after the man who designed it, Robert Wilhelm Bunsen, a German chemist.

The first bunsen burner was designed to operate on a supply of coal-gas, but many bunsen burners are now designed to operate on natural gas.

The parts of a bunsen burner

Unscrew the *chimney* of a bunsen burner. To do this, turn the chimney in an anticlockwise direction. Then examine the parts of the burner. Each part has a purpose.

Chimney: draws upwards a fast-moving stream of gas or a mixture of air and gas.

Air-holes: allow air to enter the chimney.

Air-regulator: controls the amount of air that enters the air-holes.

Jet: makes a thin stream of gas which enters the chimney.

Screwing: attaches the chimney to the base.

Flexible tube: brings gas from the supply to the burner; it allows the burner to be used in any direction.

Inlet tube: where the flexible tube is attached, and where the gas enters the burner.

Base: wide, flat and heavy so that the burner is not easily knocked over. Now screw the chimney back into its place.

Using a bunsen burner

Practise using a bunsen burner.

Close the air-holes by turning the regulator. Strike a match or light a spill. Hold the flame over the top of the chimney. Then turn on the gas. The gas ignites and burns with a silent, flickering, sooty, slightly luminous flame. Make the flame larger or smaller by turning the gas tap.

Open the air-holes. The gas now burns with a roar. The flame is noisy, steady, almost colourless, very hot and free from soot. This is the flame that you will use when you want to heat something very strongly.

Close the air-holes partly. What happens to the flame?

There are *three* important things to remember when you are using a bunsen burner.

1. *The gas tap alters the size of the flame.*
2. *The air-regulator alters the hotness of the flame.*
3. *You must take precautions in order to prevent accidents.*

Precautions when using a bunsen burner

1. Do not hold any part of your body over or near a bunsen burner flame.
2. Light the match or spill before you turn on the gas.
3. Do not turn on the gas and leave the burner unlit; avoid turning on the gas accidentally.
4. Turn off the gas when you have finished using a bunsen burner; do not leave it on and unattended.
5. If you suspect that there is a gas leak, turn off the gas and inform your teacher.
6. Hold whatever is being heated in the outer part, and not the inner part, of the flame.

Backfiring

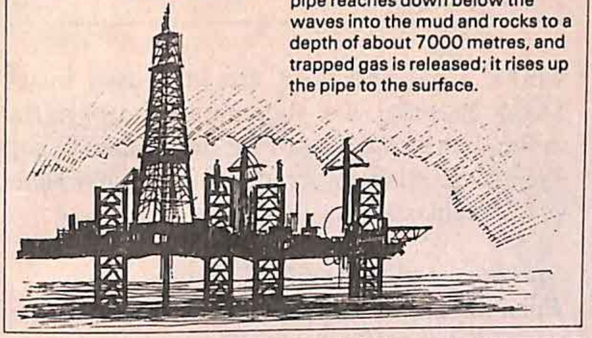
A bunsen burner sometimes *backfires*, or *strikes back*. This occurs when there is only a small flow of gas, as happens when the burner is not turned on fully before it is lit. The flame travels down the chimney and lights the gas at the jet. If backfiring should occur, turn off the gas and close the air-holes. Then turn on the gas fully and relight the burner.

Gas burners

Gas-rings, fires and pokers operate in much the same way as the bunsen burner. They have air-inlets. The flow of air to a gas-ring is usually controlled by an adjustable screw.

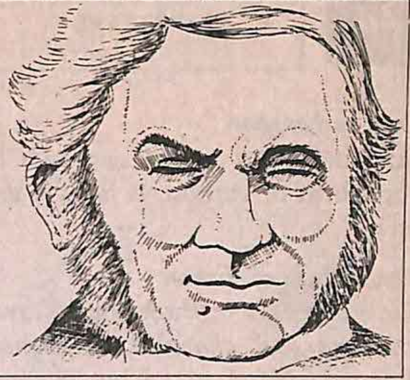
NORTH SEA GAS

From this floating platform, a drill pipe reaches down below the waves into the mud and rocks to a depth of about 7000 metres, and trapped gas is released; it rises up the pipe to the surface.

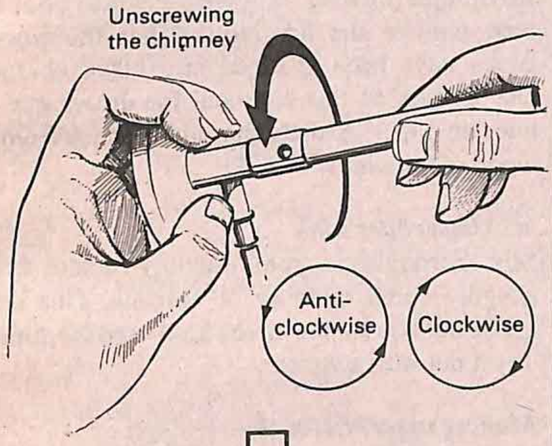


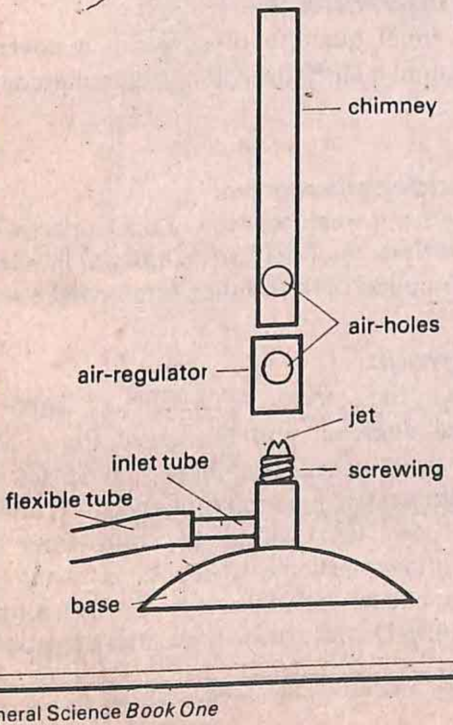
ROBERT WILHELM BUNSEN

1811-1899

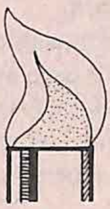


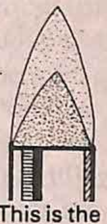
THE PARTS OF A BUNSEN BURNER





USING A BUNSEN BURNER

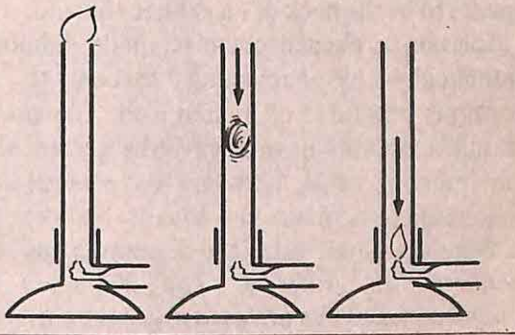




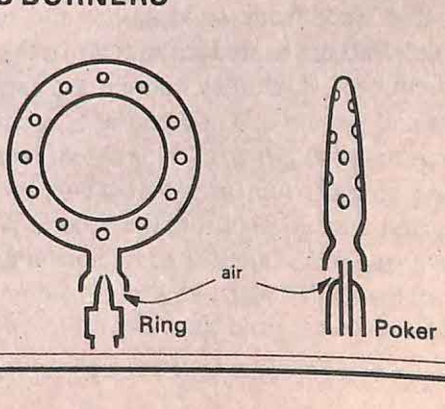
AIR-HOLES CLOSED	AIR-HOLES OPEN
Gas only	Gas and air
Silent	Noisy
Flickering	Steady
Luminous	Non-luminous
Sooty	Clean
Hot	Very hot

This is the flame that you use for heating things

STRIKING BACK



GAS BURNERS



28 Carbon

Coal and carbon

Coal and wood contain carbon. Coke is a fairly pure form of carbon. It is used as a smokeless fuel.

Three kinds of carbon

Carbon exists in three main forms—*diamond, graphite* and *charcoal.* Diamond looks very different from charcoal, but, chemically, they are the same material. Diamond, graphite and charcoal are called the *allotropes of carbon.*

Graphite, which is black and soft, is mined in Sri Lanka. It can be made artificially. It is used as a lubricant for machinery, for making contacts in batteries and electrical machines and, when mixed with clay, for making the leads of pencils. Pencil leads are not made of real *lead.*

Diamonds, which are believed to have been formed by the enormous pressures in volcanic rocks acting upon vegetable material, are used as jewellery and for making cutting tools. The *blue earth* of the Kimberley Mine in South Africa appears to be the neck of an extinct volcano.

Moissan, a French chemist, made diamonds synthetically by subjecting carbon to the enormous pressures of molten iron. The cost of making diamonds in this way was greater than their market value and so the process was discontinued. A new and cheaper process for making very small industrial diamonds has been discovered in America. The diamonds are *sandgrain* size. They are used in grinding wheels.

Charcoal

Charcoal is made from wood, bones and sugar. These materials are heated without air so that the other chemicals which they contain are expelled as gases and vapours. Wood charcoal is used in making gunpowder, as *artist's charcoal,* and for absorbing gases. *Respirators,* or *gas-masks,* of the kind that were used during the Second World War, as a protection against some poison gases, have containers filled with tiny grains of charcoal. Charcoal was once used as a clean fuel in iron works. Coal and coke are now used instead. Sugar charcoal is a very pure form of carbon. Animal charcoal is used for decolourizing sugar syrups. Soot is another form of carbon. *Printer's ink* contains carbon.

Making wood charcoal

Fill a metal can with small sticks of wood. Punch a small hole in the lid. Heat the can strongly. Ignite the gases and vapours which issue from the hole in the lid. When the flame goes out, discontinue heating. Allow the can to cool and then remove the lid. Notice that the wooden sticks have been changed into black charcoal. Use a stick of this charcoal for drawing a few lines on paper. Artist's charcoal is made from the wood of the willow tree.

Making printer's ink

Mix thoroughly a small quantity of soot with a roughly equal quantity of vaseline. This ink is crude but it is similar to the kind used by printers. Try it out with a *linocut.*

Making sugar charcoal

Heat a small quantity of sugar in a covered crucible until a black deposit of sugar charcoal is formed.

Decolourizing with charcoal

Boil together a weak solution of tea or port wine with a few pieces of *activated charcoal* in a test-tube. The colour of the solution is removed.

Making pencils

Make a pencil from a mixture of soot or powdered charcoal and plaster of Paris. Mix together equal quantities of the soot and plaster in a jar. Add water to the mixture and stir it until it has the consistency of thick cream. Pour the mixture into a plasticine mould. After 20 minutes or so, the plaster will have set to give you a thick black pencil. Use it to draw a few lines on paper.

SOME FORMS OF CARBON

Coal

Coke

Graphite

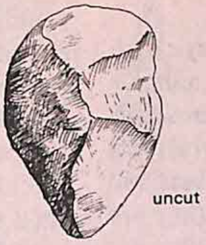
Diamond

Wood charcoal

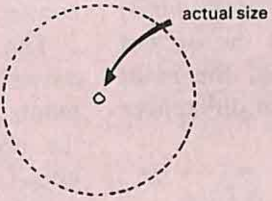
Animal charcoal

Sugar charcoal

DIAMONDS



Natural diamond

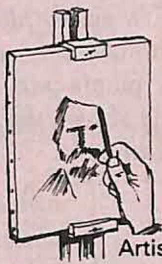


Synthetic diamond

SOME USES OF CHARCOAL

Gunpowder

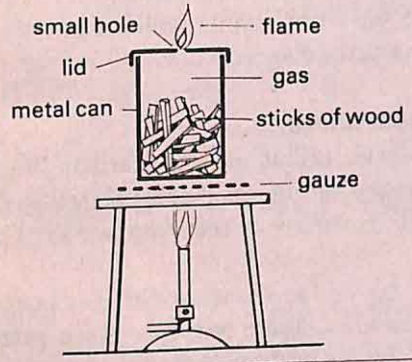
Respirators



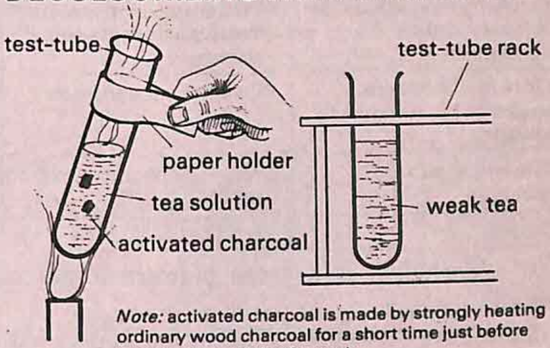
Artist's charcoal

Printer's ink

MAKING WOOD CHARCOAL

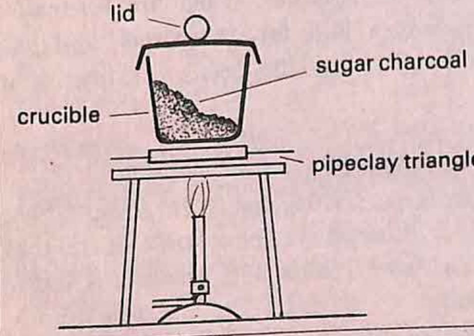


DECOLOURIZING WITH CHARCOAL

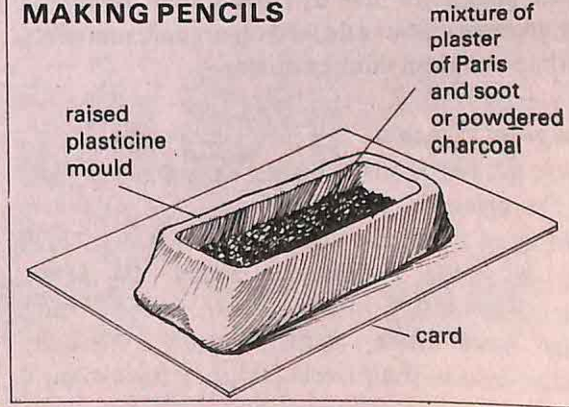


Note: activated charcoal is made by strongly heating ordinary wood charcoal for a short time just before the experiment is performed

MAKING SUGAR CHARCOAL



MAKING PENCILS



29

The Plant Kingdom

Living things

What are living things? In what ways are they different from other things? Plants and animals feed, breathe, grow, move, reproduce themselves and respond to *stimuli*. Rabbits shiver when it is cold. Leaves grow towards sunlight. Buckets and teapots do none of these things because they are not alive; they have never been alive.

Plants and animals

All living things are either *plants* or *animals*. Sometimes, the animals are called the *animal kingdom*, and the plants are called the *plant kingdom*. This table shows the main differences between plants and animals.

Plants	*Animals*
Do not travel about	Move about
Usually green in colour (chlorophyll)	All colours
Feed on carbon dioxide gas in the atmosphere and mineral salts in the soil	Feed on *organic* materials, that is, plants and other animals
Grow in all directions; shapes and sizes constantly changing	Definite shapes and sizes
Not very sensitive to stimuli	Very sensitive; nerves and brains
Simple	Complicated

Note: *chlorophyll* is a green pigment found in plants.

There are exceptions. Oysters and sea-anemones are stationary animals. Some tiny water plants are able to move about. *Fungi* are not green in colour and feed on organic materials. Perhaps you can think of others.

The plant kingdom

There are two kinds of plants—the *flowering* and the *flowerless*.

Most of the plants you see have flowers. There are two kinds of flowering plants—the *herbs*, which have soft stems, and the *trees* and *shrubs*, which have woody stems. Shrubs are usually smaller in size than trees, and they have several woody stems arising from the ground instead of one main trunk. The *herbaceous* flowering plants do not have woody stems. Bluebells and buttercups are herbaceous.

Trees are either *deciduous* or *coniferous*. Deciduous trees, such as the oak and the ash, shed their leaves in autumn and their seeds are contained in *fruits*. Coniferous trees form *cones* to hold their seeds, and they are usually, but not always, *evergreens*. Spruce and cedar are conifers.

The flowerless plants include *ferns, horsetails, mosses, algae, fungi* and *bacteria*. The giant plants growing in the primeval forests from which the coal seams were formed were ferns and horsetails. The flowerless plants are generally simpler than flowering plants. Fungi are not green because they do not contain *chlorophyll;* they feed on decaying vegetation. Bacteria—the ones which cause diseases are sometimes called *germs*—are very tiny plants which can only be seen with the aid of a *microscope*.

Outdoor observations

If you observe plants in the garden, in the countryside and on the seashore, you will notice the tremendous variety in their shapes, sizes and colours.

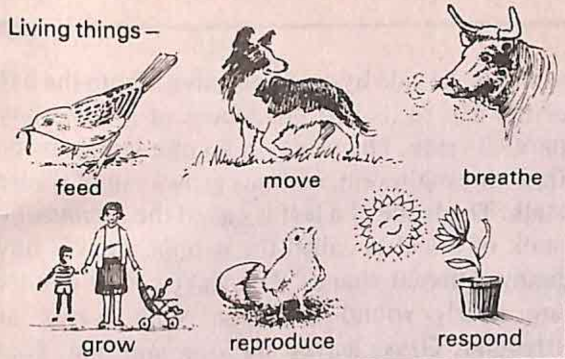
You will notice the seasonal changes in plant growth. In winter, there are few green plants. With the exception of the evergreens, the trees are gaunt and bare. In spring, green shoots appear above the ground and tree buds burst into leaf and flower. In summer, fruits are formed. In autumn, leaves and flowers wither and leave behind fruits containing seeds for next year's plants.

Nature works for us

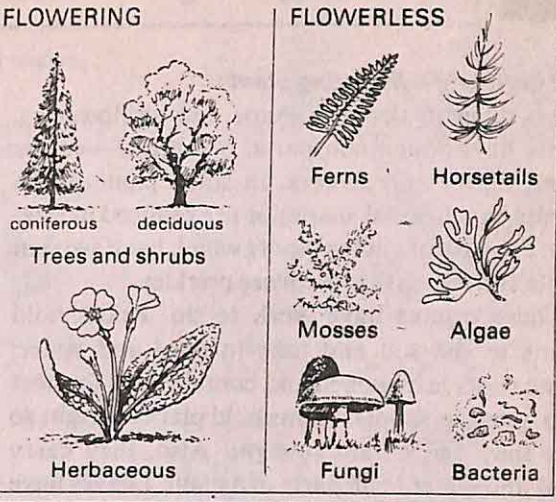
We make nature work for us in many different ways. The illustrations show some of the things we obtain from plants and animals. There are many more.

LIVING THINGS

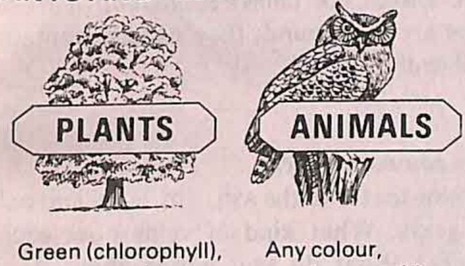
Living things –



PLANT KINGDOM

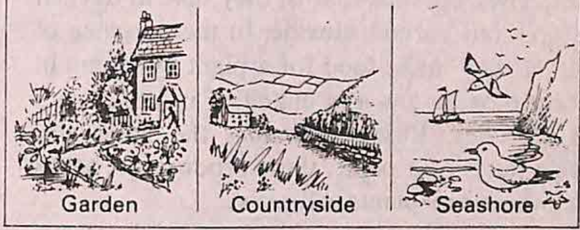


PLANTS AND ANIMALS

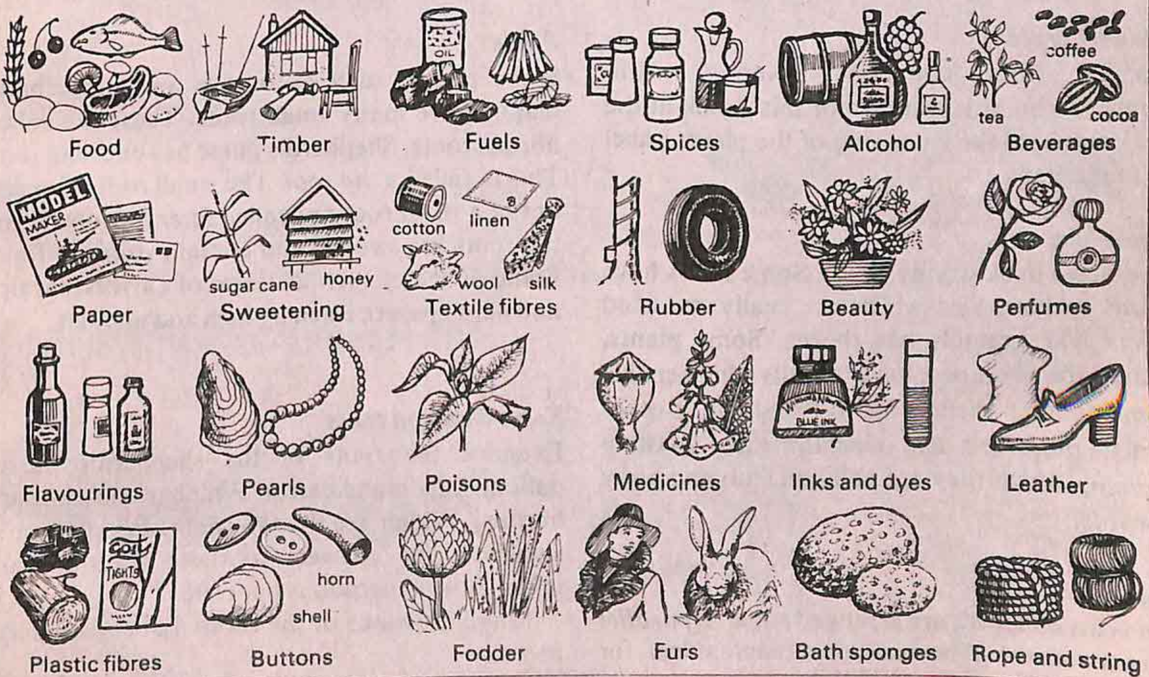


Green (chlorophyll), stationary, simple, mineral food, insensitive	Any colour, moving, sensitive, organic food, complicated

OUTDOOR OBSERVATIONS



NATURE WORKS FOR US



30 Flowering Plants

The organs of a flowering plant

Plants differ in size and shape, but all flowering plants have four main parts, or *organs—roots, stems, leaves* and *flowers*. In some plants these organs have special shapes or are reduced in size, as in the case of cactus plants which have swollen stems and leaves that are mere prickles.

These organs have work to do. Roots hold plants in the soil and take in food and water. Some roots are swollen and contain food for next year's young shoots. Stems hold plants upright so that they can obtain sunlight. Also, they carry food and water to all parts of a plant. Leaves have much work to do. They give out, or *transpire*, water. They breathe, that is, they take in oxygen and give out carbon dioxide. In the presence of sunlight they make food for a plant by taking in carbon dioxide gas and changing it into sugars and starches. Flowers contain the male and female parts of a plant; these produce the seeds from which new plants will grow.

There is much variety in the forms of the stems, leaves, roots and flowers of plants.

A flowering plant

Examine some common flowering plant. Shepherd's purse is suitable for this. Look at the four organs. Make a drawing of the plant. Label the four organs.

Trees

Trees have thick woody stems. Some stems have thorns and prickles which are really modified leaves. The bramble has thorns. Some plants, such as the sweet pea, have tendrils which enable them to attach themselves to the stems of other plants. Bindweed and clematis have twisting stems by which they are able to climb and grow upwards.

Leaves

The veins on leaves are arranged either in *parallel* or as a *network*. The veins on a plantain leaf, for example, lie side by side and extend from the base of the leaf to its tip. The leaves of grasses have parallel veins. The veins on an oak leaf grow out from one main vein, and this grows out of the leaf stalk. The blade of a leaf is called the *lamina*. The stalk of a leaf is called the *petiole*. Leaves have many different shapes. The leaves of an elm tree are nearly round in shape. Oak leaves are irregular. Grass leaves are long and thin. Some leaves are divided into several small *leaflets*. These leaves are called *compound leaves*. Ash leaves are compound; they usually contain nine small leaflets.

Some common leaves

Examine leaves of the ash, elm, holly and oak and any grass. What kind of veins does each leaf possess? What do you notice about the holly leaf?

Make drawings of the leaves. Label the parts of each leaf—petiole, lamina, leaflet, etc.

Roots

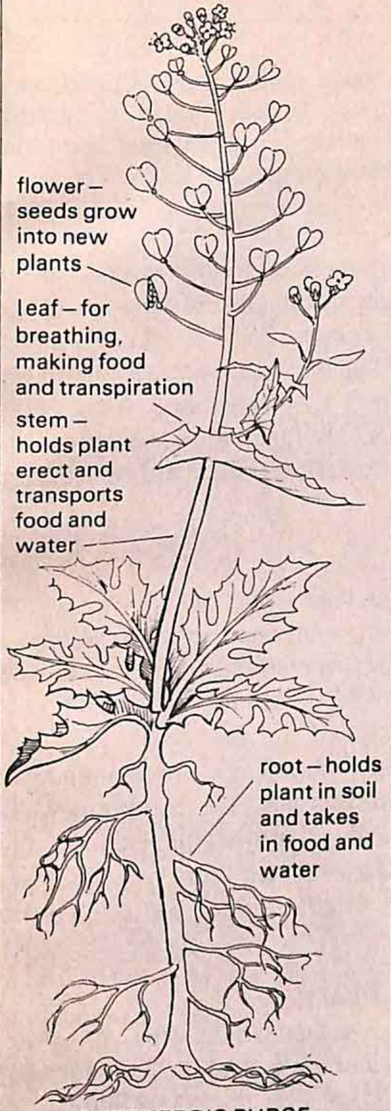
Some plants, such as onions and other bulb-plants, have many small roots. These are called fibrous roots. Shepherd's purse has one long root. This is called a *tap root*. The small roots growing out of a main root are called *lateral roots*. Some tap roots are swollen and contain stores of food. Some of these, such as those of carrots, turnips and parsnips, are eaten by men and animals.

Some common roots

Examine the roots of the shepherd's purse, daffodil, onion and carrot. Which of the roots are fibrous? Which are the tap roots? Which root is swollen? The answers to these questions are given in the illustrations opposite.

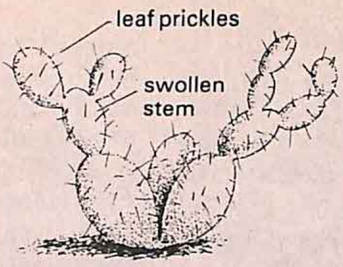
Make drawings of the roots. Label the lateral roots.

FLOWERING PLANT


flower – seeds grow into new plants
leaf – for breathing, making food and transpiration
stem – holds plant erect and transports food and water
root – holds plant in soil and takes in food and water

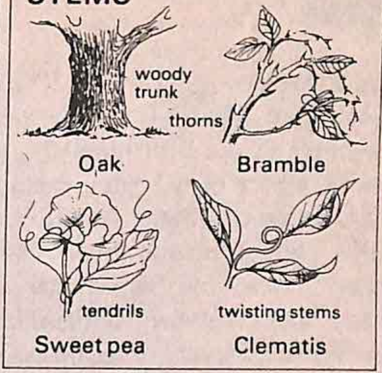
SHEPHERD'S PURSE

CACTUS PLANT

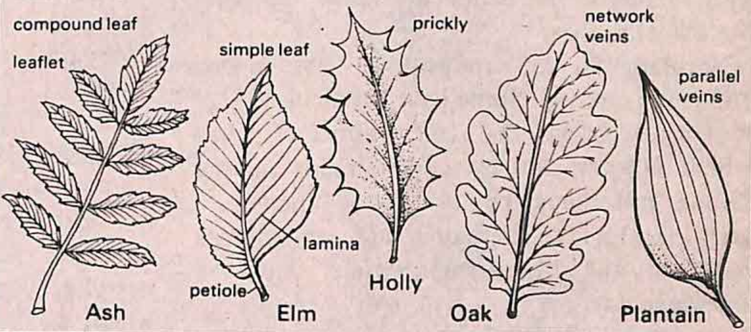


Prickly pear cactus

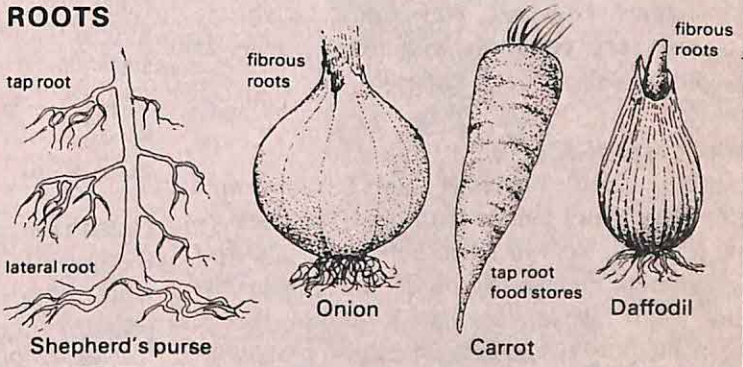
STEMS



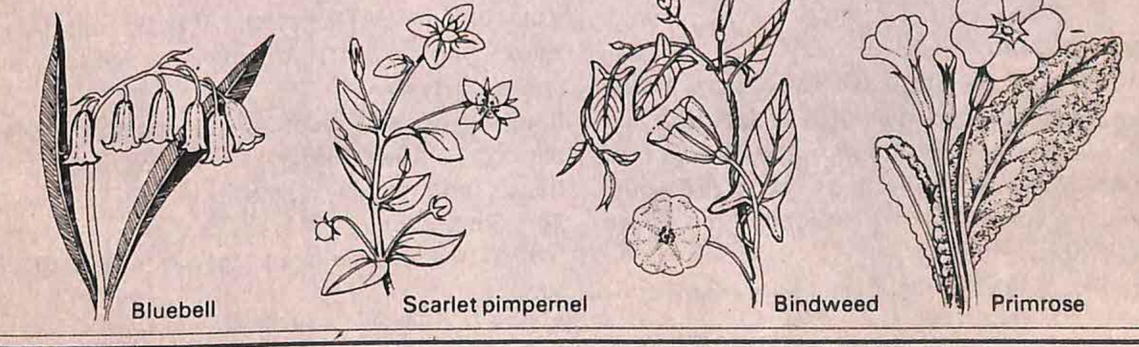
LEAVES



ROOTS



VARIETY IN FLOWERING PLANTS



31 Plant Families

Plant families

Lions and tigers are similar animals. They are members of the "cat family". Dogs and wolves are members of the "dog family". In the same way, botanists (botanists are the scientists who study plants) have grouped plants into families. Peas, beans and clover are called *legumes*. Botanists have names for these families. Legumes are called *Leguminosae*. Grasses belong to the *Gramineae* family. The rose, hawthorn and cherry belong to the *Rosaceae*. There are many other plant families.

The plants in the same family have certain features in common. Some have the same kind of flower arrangement, the same number of petals on their flowers, and leaves of similar shapes. Bulbous buttercups, peonies, wood anemones, marsh marigolds, clematis and columbines belong to the "buttercup family", or the *Ranunculaceae*.

You are not expected to remember these long Latin names. However, you should be able to recognise very common wild plants, such as bluebells, cowslips, foxgloves, etc.

The names of plants

Be careful with the names of plants because some plants have more names than one. The cuckoo-pint, which flowers in April and May, has over fifty different names. Some of them are: wild arum; arum lily; wake-robin; lords and ladies; jack-in-the-pulpit; soldiers and sailors; parson-in-his-smock; friar's cowl; red-hot poker; jack-by-the-hedgerow; bishop's throne.

Poisonous plants

Many plants have attractive flowers and fruits. These fruits look "good enough to eat". *But you must not eat any wild plants*. Some innocent looking plants are poisonous. Here are some common plants which are poisonous. There are many others.

Foxglove; deadly nightshade; cuckoo-pint; monkshood; poppy; laburnum; henbane; yew; holly; honeysuckle; guelder rose; buckthorn; bitter-sweet; hemlock; ivy; mistletoe; wayfaring tree; some toadstools and other fungi.

Food plants

Many plants are used as food, but only certain organs are eaten. In the case of apples, oranges and strawberries, it is the fruit which is eaten. Peas, beans and peanuts are seeds. Rhubarb and celery are stems. Cabbages and lettuces are leaves packed closely together. Cauliflowers and asparagus are flowers. Turnips and radishes are roots.

Cereal plants

Cereal plants, such as wheat, oats, barley, maize, rye and rice, are cultivated grasses. Wheat is believed to have been cultivated from a grass that is still growing wild on Mount Hermon, in Syria, which is mentioned in the Bible. Common grasses, though smaller, are similar in appearance to the cereals. The bamboo and the sugar cane are members of the grass family. Grasses have flowers but they are small and usually without bright colours, so they are not easily seen.

Cereals and grasses

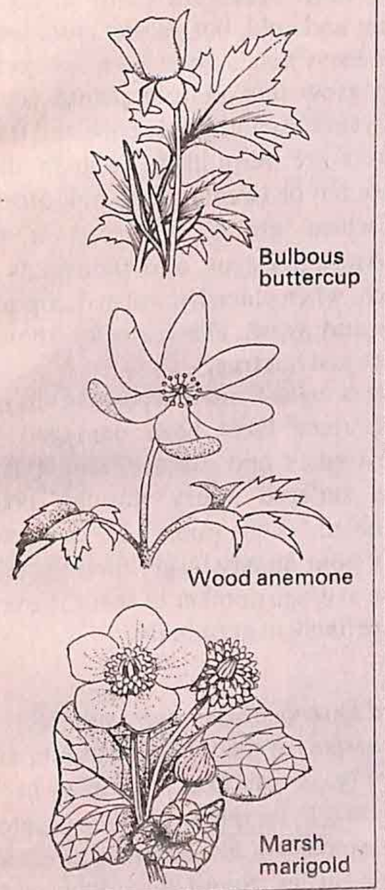
Examine and make labelled drawings of ears of wheat, barley and oats and a few common grasses, such as vernal, hare's-tail and timothy—if they are available.

Making a collection

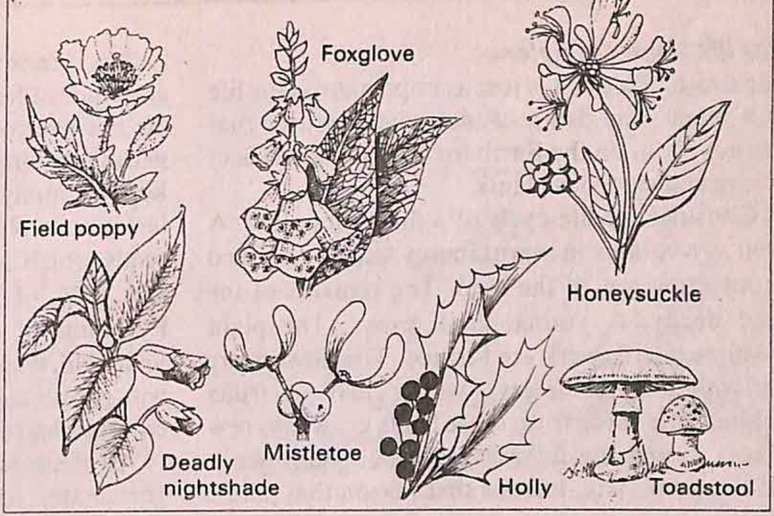
You could make at least *one* of these collections, using photographs, tracings, drawings and printed pictures:

Garden plants; grasses; cereal plants; climbing plants; common shrubs; conifers; deciduous trees; food plants; plants which yield textile fibres; poisonous plants; plants used in medicine; fodder plants; evergreens; plants with unusual shapes.

SOME MEMBERS OF THE BUTTERCUP FAMILY

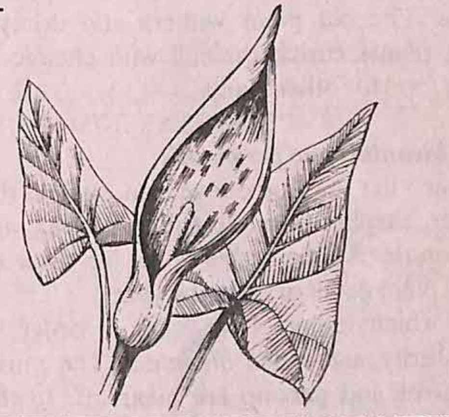


SOME POISONOUS PLANTS

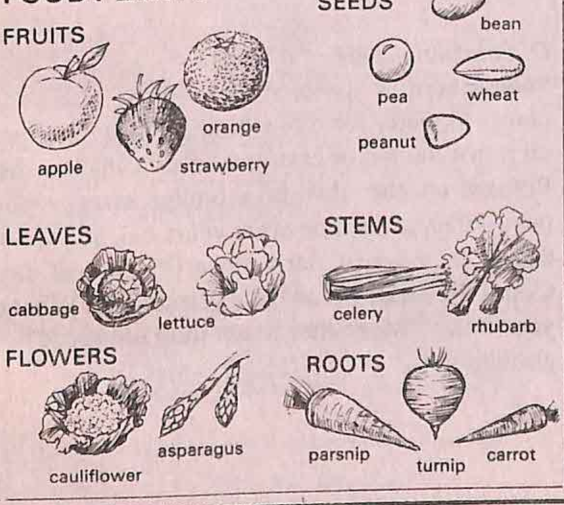


CUCKOO-PINT

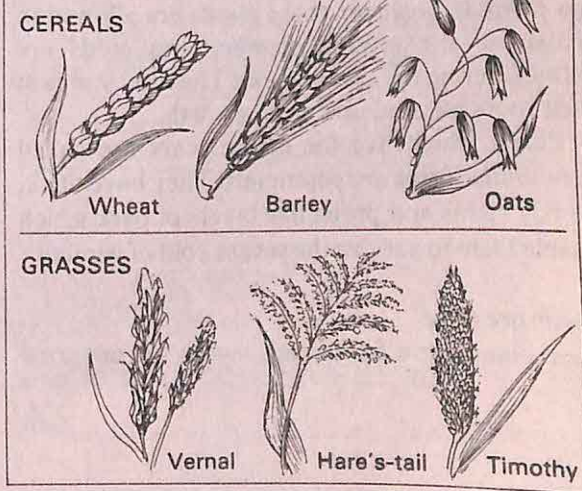
The cuckoo-pint has more than 50 different names



FOOD PLANTS



CEREALS AND GASSES



32 New Plants

The life history of a plant

The death of a plant is just as important as the life of a plant. The death of old plants ensures that there is room on the Earth for new generations of young and vigorous plants.

Consider the life-cycle of a flowering plant. A seed *germinates* in warm damp soil. A root and shoot grow out of the seed. The remains of the seed decay. A young plant grows. The plant matures and flowers are formed. The flowers are *pollinated*. The flowers wither leaving fruits behind. The seeds from these fruits grow into new plants during the following season. Many seeds do not germinate. It is for that reason that plants produce many seeds; then a few, at least, will germinate. The old plant withers and decays. Decaying plants enrich the soil with chemicals which are food for other plants.

Annuals, biennials and perennials

Plants which live for only one season, such as the cornflower, shepherd's purse and sweet pea, are called *annuals*. All the stages in the life-cycle of an annual plant occur in the same year.

Plants which require two years in order to reach maturity are called *biennials*. The musk thistle, carrot and parsnip are biennials. In the case of carrots and parsnips, large swollen roots are formed during the first year of growth. These are eaten. If, however, these plants are allowed to remain in the ground, flowers and seeds are formed during the second year. The food stores in their roots are used up during growth.

Plants which live for many years are called *perennials*. Trees are perennials. They have thick, woody stems and protective layers of bark which enable them to survive the severe cold of winter.

Seeds are alive

Most plants grow from seeds. Seeds will not grow if they are not alive. Seeds are easily killed by extremes of heat and cold, but, in any case, seeds do not live for ever. Seeds kept for a few years germinate and grow into mature plants. Seeds kept for many years do not. Seeds collected from last year's plants are more likely to grow than seeds which are ten or twenty years old. Stories are told of wheat grains preserved in the Pyramids of Ancient Egypt, and thousands of years old, which, when placed in warm damp soil, will germinate and grow. These stories, though entertaining, are just not true.

All the seeds bought from a seedsman do not germinate, for some have been damaged by temperature extremes and disease, and a few, perhaps, have suffered injury through being carelessly handled. The public is protected against seeds of poor quality by germination tests which show the average number of seeds in every hundred that are likely to germinate.

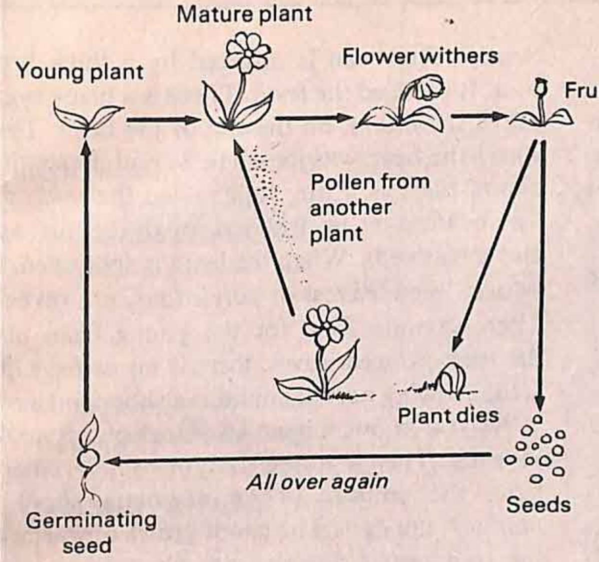
Seeds are killed by temperature extremes

Boil and heat samples of peas, using a beaker and a test-tube. Freeze another sample in a refrigerator. Leave a sample of peas untreated. Place the four samples on moist flannel or cotton wool in shallow dishes. Stand them in a warm place for several days. Which seeds germinate?

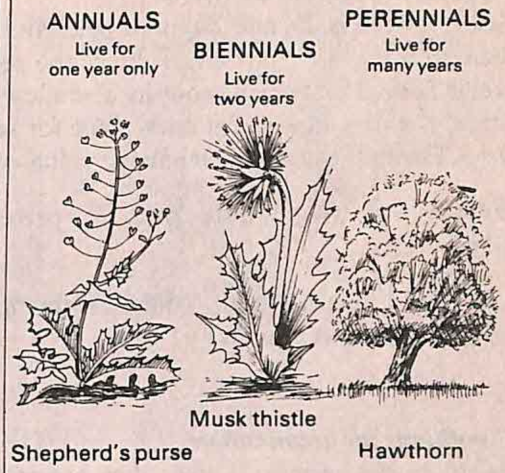
Old and new seeds

Soak about a hundred peas from last year's plants in water for a few hours. Place these peas on moist flannel or cotton wool in a shallow dish. Prepare another dish in a similar manner using peas which are ten or more years old. Stand both dishes in a warm dark place for several days. Count the seeds which have germinated. What do you notice? More new seeds than old seeds have germinated.

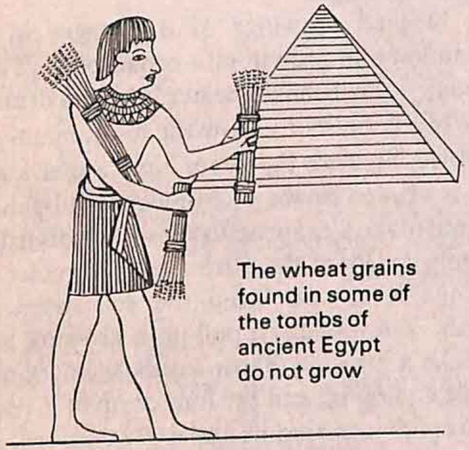
THE LIFE HISTORY OF A PLANT



THE LIFE OF A PLANT

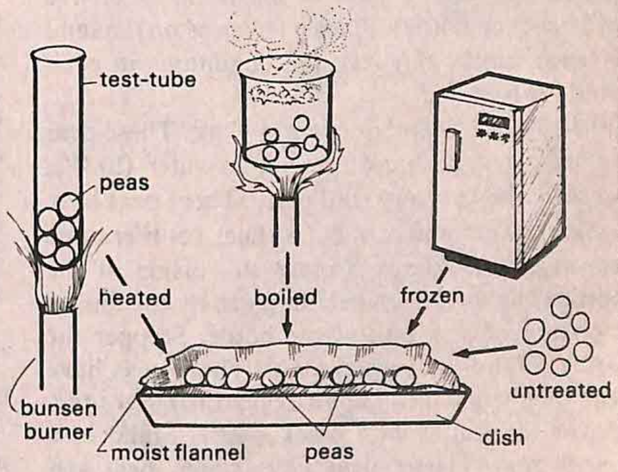


WHEAT IN ANCIENT EGYPT

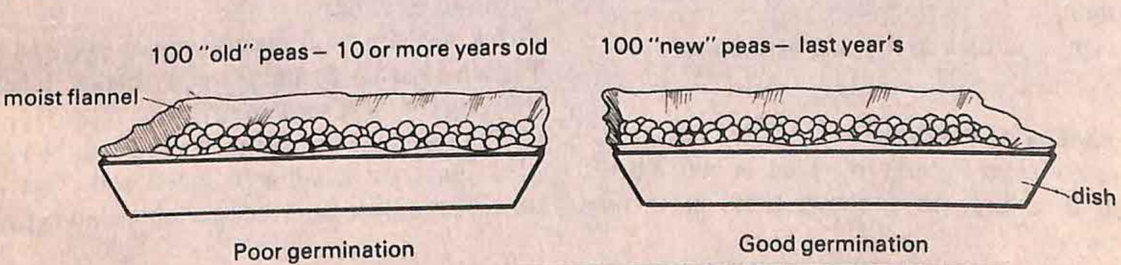


The wheat grains found in some of the tombs of ancient Egypt do not grow

SEEDS ARE KILLED BY TEMPERATURE EXTREMES



OLD AND NEW SEEDS


100 "old" peas – 10 or more years old
100 "new" peas – last year's
moist flannel
dish
Poor germination
Good germination

33

Growing Seeds

A percentage germination test

Count out exactly one hundred peas and soak them in water for a few hours. Place the peas on moist flannel or cotton wool in a shallow dish. Stand the dish in a warm dark place for several days. Count the peas which have germinated.

Number of germinating peas = percentage germination

A more reliable result would be obtained by using a thousand peas. Why?

Conditions for germination

Seeds do not germinate when they are cold, dry or without oxygen. Light is essential for the growth of a plant, but seeds germinate better in darkness.

Place layers of sand at the bottoms of five wide-necked bottles. Place a few peas on the sand in each bottle. Arrange the conditions in each bottle as follows.

(a) *Dry sand.* Stand in a warm place. These peas have oxygen, heat and light but no water. (b) *Wet sand.* Stand in a very cold place. These peas have oxygen, water and light but no heat. (c) *Wet sand.* Sprinkle iron filings around the inside of the bottle. The filings are held in place by the film of moisture on the wall of the bottle. Stopper the bottle. Stand in a warm place. These peas have water, light and heat but no oxygen. (d) *Wet sand.* Cover the bottle with black paper. Stand in a warm place. These peas have water, heat and oxygen but no light. (e) *Wet sand.* Stand in a warm place. These peas have water, oxygen, heat and light.

In which bottles do the peas germinate?

The parts of a seed

There are several parts to a seed. A broad bean, which is a large seed, shows these parts very clearly. The bean is covered by a thick brown coat. It is called the *testa*. There is a black region, called the *hilum,* on the top of the bean. This is where the bean was joined to its pod. Beneath the hilum, there is a tiny hole called the *micropyle.* The bean takes up water through the micropyle and then swells. When the bean is split open, two swollen seed-leaves, or *cotyledons,* are revealed. These contain food for the young bean plant. Between the seed leaves, there is an *embryo.* This is the growing part; it contains a shoot and a root.

As you know, a bean swells when it is soaked in water. Then a young root, or *radicle,* emerges from the embryo. Then a young shoot, or *plumule,* appears. The shoot grows upwards and the root grows downwards. The roots growing out of the radicle are called *lateral roots.*

Germination stages

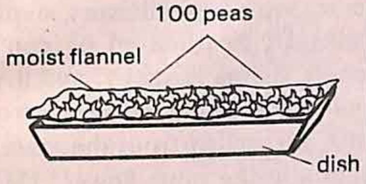
Make labelled drawings of the stages in the germination and growth of a broad bean. To do this, soak a few beans in water. Make a drawing of one of the beans to show the testa, hilum and micropyle. Squeeze the bean. Notice that a little water is exuded by the micropyle. Split open the bean and make a drawing to show the cotyledons and embryo. Plant the other beans in moist soil contained in a pot. Keep the soil moist. At intervals of a few days, pull up a growing bean and make a drawing. Show a radicle emerging, a plumule emerging, and the formation of a young seedling with lateral roots and *root hairs.*

Growing seedlings

Grow seedlings of maize, castor oil and the French bean. Examine and make labelled drawings of these seedlings.

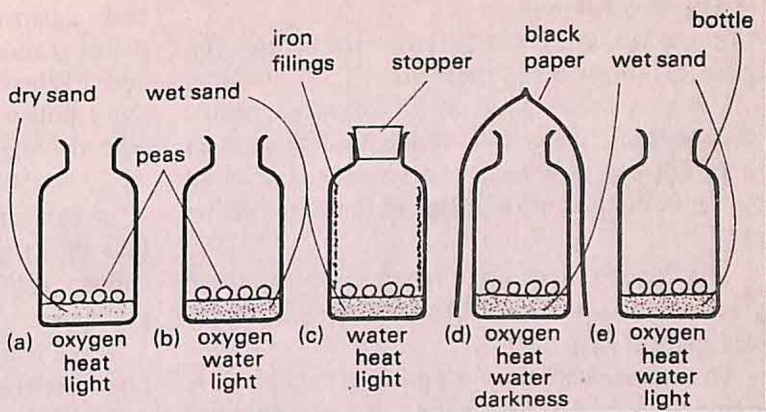
The seedlings can be grown around the inside of a glass jar filled with moist soil. You can observe these seeds as they germinate and grow.

PERCENTAGE GERMINATION TEST

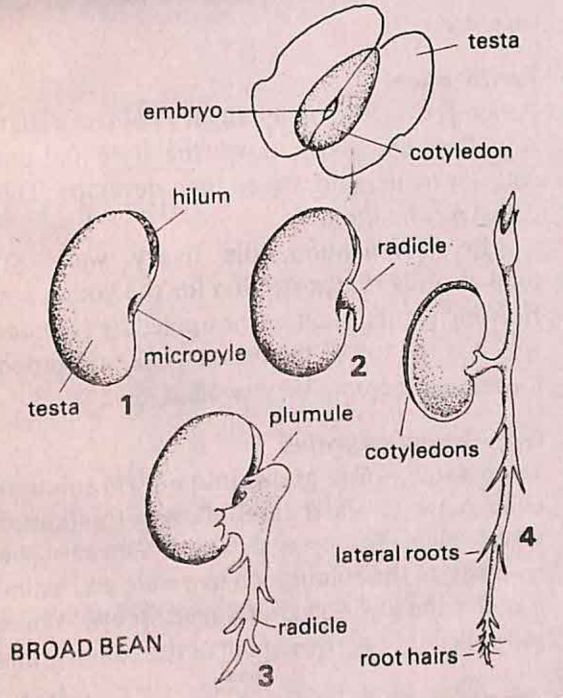


Number of germinating peas
= % age germination

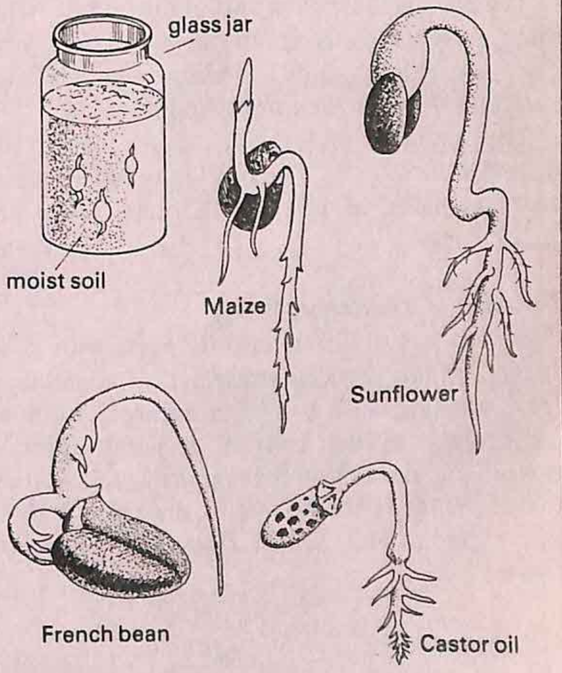
CONDITIONS FOR GERMINATION



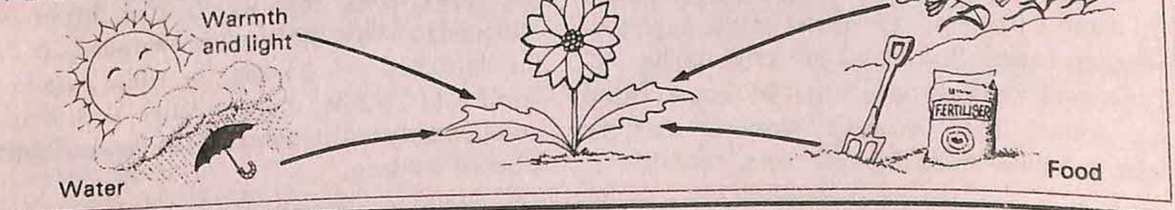
GERMINATION STAGES



GROWING SEEDLINGS



PLANT GROWTH



34 Flowers and Seeds

The parts of a flower

A flower has four distinct parts—the *corolla*, the *calyx*, the *stamens* and the *pistil*.

The corolla is made up of coloured petals. They attract the insects which visit flowers in search of *nectar*. Nectar is a sweet, sugary fluid that is contained in *nectaries* at the bases of the petals.

The calyx is made up of *sepals*. They are small green leaves which protect the flower during the bud stage of its growth.

The stamens are the male parts of the flower. A stamen has two parts—a long thin *filament* and an *anther*. The anther, when ripe, bursts open and releases yellow *pollen grains*.

The pistil is the female part of the flower. It has three parts—the *stigma*, the *style* and the *ovary*. The ovary contains *ovules*, which, after *pollination* and *fertilization*, become seeds.

The stamens and the pistil are called the *reproductive organs*. The pistil may have several separate parts, as in the buttercup. These are called *carpels*.

The parts of a buttercup flower

Pull a buttercup flower into its parts with your fingers. Make labelled drawings of a petal, a sepal, a stamen and a pistil or a carpel. Look at the nectary at the base of a petal under a magnifying glass. Notice the pollen grains on an anther. What is the colour of the petals? How many petals and sepals does the buttercup possess?

Pollination

Pollination occurs when the pollen grains from an anther fall on to a stigma.

In *cross-pollinated* plants, the pollen is carried from the anthers of one flower to the stigma of another flower. Buttercups are cross-pollinated. Cross-pollination is carried out by insects, wind and water. Bees do useful work in carrying pollen. A bee, searching for nectar, brushes its body against the anthers of flowers. Some of the pollen grains become loosely attached to its hairy body. When the bee visits other flowers, some of these pollen grains are brushed off by contact with the stigmas. A stigma is sticky, and it can easily hold the pollen grains that fall on to it.

In some plants, the pollen from the stamens falls on to a stigma in the same flower. This is called *self-pollination*. Chickweed is self-pollinated.

Some plants, such as the hazel, oak and alder, have separate male and female flowers, and pollination occurs when the male flowers shed pollen grains on to the stigmas of the female flowers. The male flowers of the hazel are called *catkins*.

Fertilization

Pollen grains feed on the sugary fluid on a stigma. A *pollen tube* grows down the style and unites with an ovule, and a seed then develops. This is called *fertilization*.

After fertilization, the ovary walls grow thicker. This is a protection for the young seeds. In some plants, such as the apple, the *receptacle*, which is the top of the flower-stalk and supports the ovary, becomes very swollen.

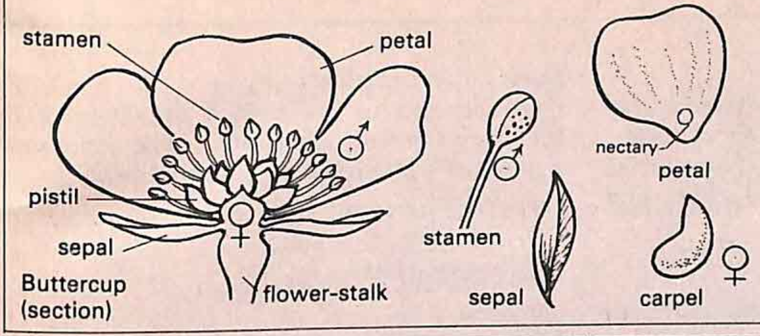
Growing pollen grains.

Drop some pollen grains into a 10% solution of cane sugar in water, and allow it to stand in a warm place for several hours. Smear a small quantity of the solution on to a slide and examine it under the low power of a microscope. You will see pollen tubes growing out of the pollen grains.

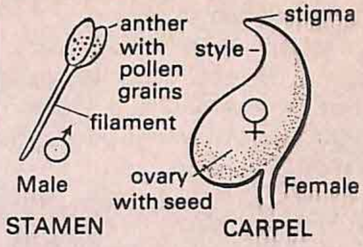
The parts of an apple

Cut an apple longitudinally, or lengthwise. Notice the flower-stalk, by which the flower was attached to a tree, the black-brown seeds, or *pips*, the thickened ovary walls, the white *pulp* in the swollen receptacle, the protective skin, or *peel*, and the withered remains of the flower. Make a labelled drawing.

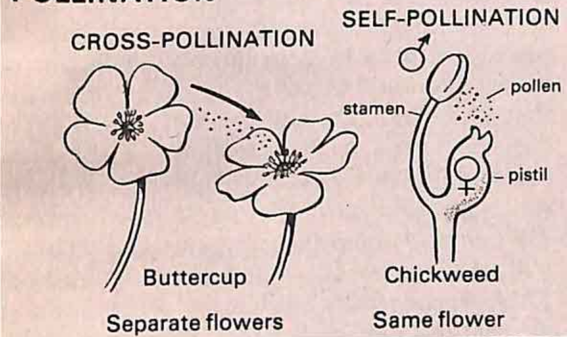
THE PARTS OF A FLOWER



THE REPRODUCTIVE ORGANS OF A BUTTERCUP

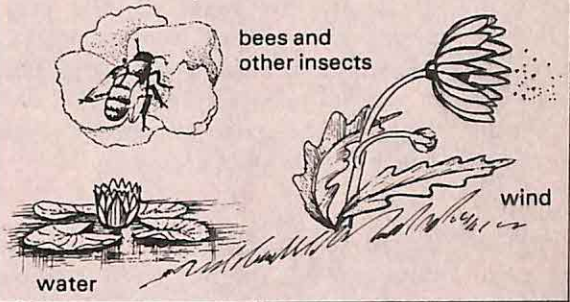


POLLINATION

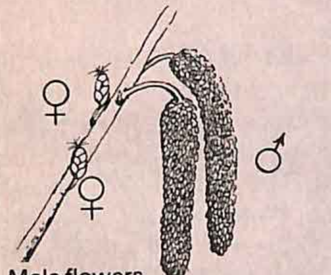


POLLINATION METHODS

Pollen is carried by –



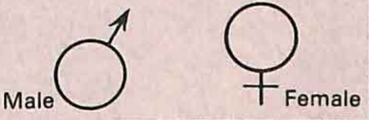
HAZEL CATKINS



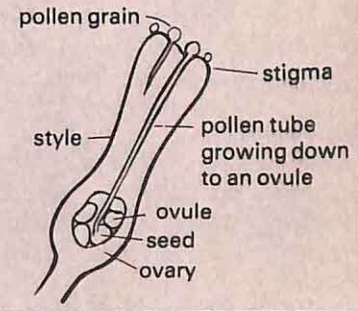
Male flowers shed pollen on female flowers

THE SEX SIGNS

Scientists use two very simple signs as a kind of shorthand for writing *male* and *female.* They can be seen on the cages in a zoo. Here they are:



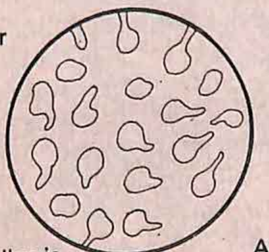
FERTILIZATION



GROWING POLLEN GRAINS

10% sugar solution

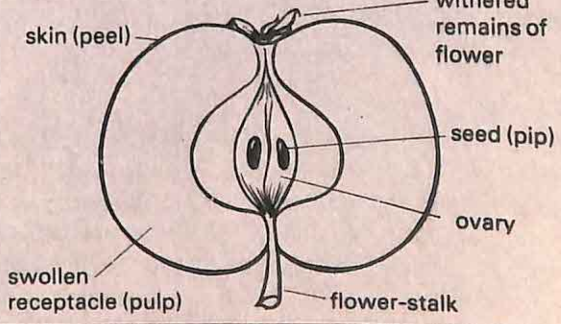
Notice the pollen tubes



Sweet pea pollen is very suitable for this

As seen under a microscope

THE PARTS OF AN APPLE



35 Flowerless Plants

Ferns and horsetails

Ferns and horsetails have roots, stems and leaves but no flowers. Their leaves are called *fronds*. Some common ferns are the holly fern, spleenwort, male fern, parsley fern, royal fern and marsh shield fern.

Mosses

Mosses have stems and leaves but no flowers or proper roots.

Algae

Algae, which include the seaweeds, are very simple plants and they do not possess special organs like roots, stems, leaves and flowers. The green scum on the sides of fish ponds and aquarium tanks and the green powdery patches on tree trunks and damp stones are algae.

Fungi and moulds

Fungi are simple plants without roots, stems, leaves and flowers. They are not green because they do not contain chlorophyll. They feed on vegetable and animal matter. Mushrooms, toadstools, puff balls, ink caps and bracket fungus are common fungi. *Moulds,* which grow on jam, cheese and damp bread, are fungi also. Fungi and moulds grow very quickly.

Reproduction

Ferns, algae, mosses, fungi and moulds reproduce themselves by means of *spores*. Perhaps you have seen some brown spots on fern fronds. These contain spores and are called *capsules*.

Mushrooms are grown from "spawn", which is a mixture of vegetable material and white threads that are called *mycelia*. These are the real mushroom plants. What you call a "mushroom plant" is the "fruit", or "fruiting body".

Growing moulds

Place a piece of moist bread in a dish. Stand it in a warm place for several days. Spores which are present in the atmosphere fall on to the bread and grow. Examine the mould which forms with a magnifying glass. Notice the tiny white threads, or mycelia.

Some flowerless plants

Examine and make labelled drawings of the following flowerless plants. The specimens named are suitable but others could be used.

(a) Fern: male fern.
(b) Alga: bladder-wrack.
(c) Fungus: mushroom.

Bacteria

Bacteria are very tiny plants. They can only be seen with the aid of a microscope that will magnify them thousands of times. They are colourless. Some of them cause diseases. Bacteria which are round in shape are called *cocci*. Rod-shaped bacteria are called *bacilli*. Spiral-shaped bacteria are called *spirilla*. The disease tuberculosis is caused by rod-shaped bacteria which are known to doctors as *tubercle bacilli*. The bacteria which cause pneumonia are cocci.

Bacteria grow on plant and animal materials. They reproduce themselves by division, that is, by splitting into two. Louis Pasteur, a French chemist, proved that *putrefaction,* or rotting, is caused by bacteria.

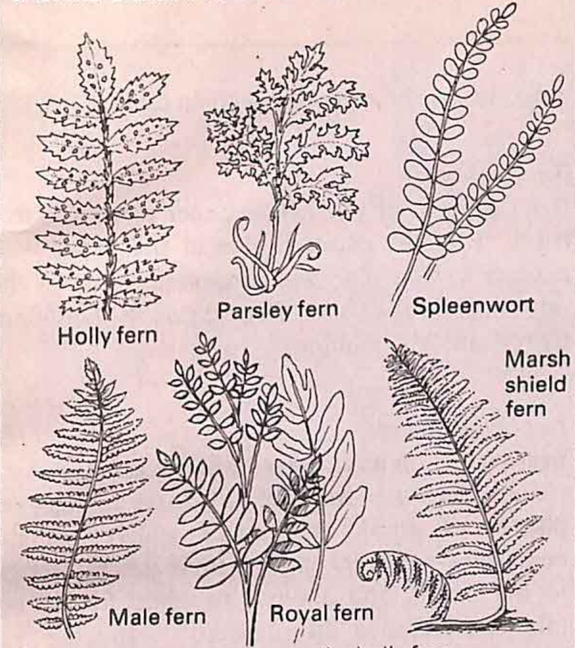
Growing bacteria

Half fill two flasks with boiled meat broth. The broth is boiled to destroy the bacteria contained in it. Seal one of the flasks with a rubber stopper. Allow both flasks to stand for about ten days, and then examine them. The broth in the unsealed flask has "gone bad". Bacteria in the atmosphere have entered this flask and fed on the meat broth. The broth in the sealed flask is still fresh.

Germs and disease

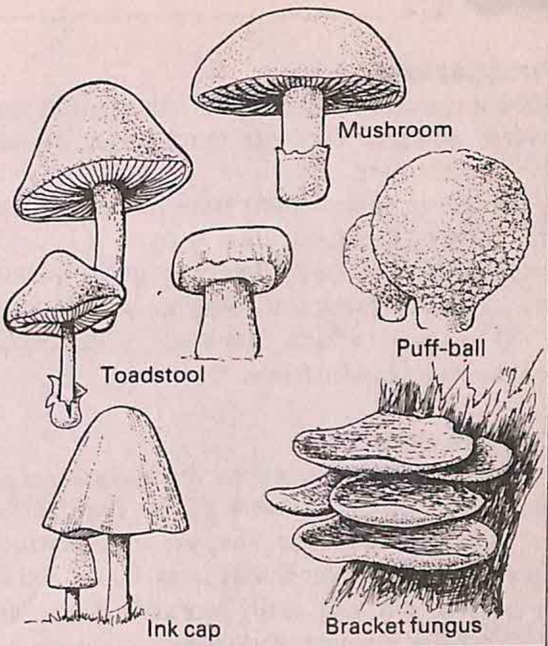
Louis Pasteur, a French chemist, introduced *pasteurization,* or the boiling of milk, to kill bacteria which could cause diseases. In practice, the temperature of the milk is raised and lowered rapidly. The sudden temperature changes kill the bacteria. A doctor sometimes *sterilizes* his instruments by dipping them into an *antiseptic* fluid; this kills bacteria. Bacteria are easily carried by rats, mice, cockroaches, fleas and houseflies. Animals which carry disease bacteria are called *vectors*.

SOME COMMON FERNS

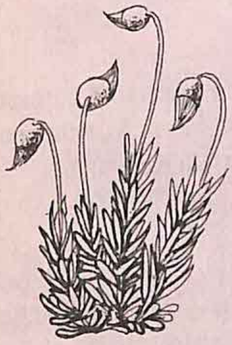


Notice the spore capsules on the holly fern

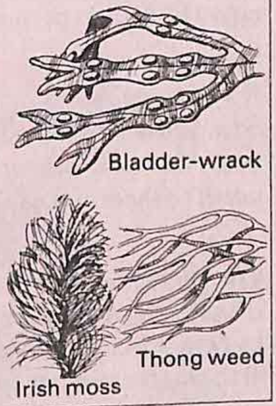
SOME COMMON FUNGI



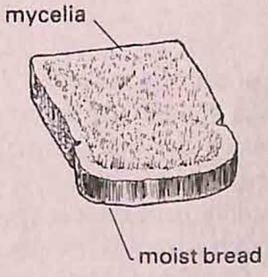
MOSS



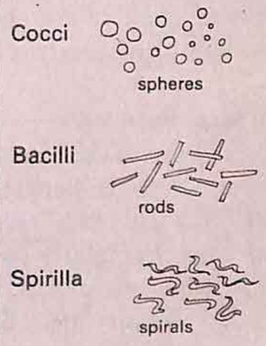
SEAWEEDS



GROWING MOULDS

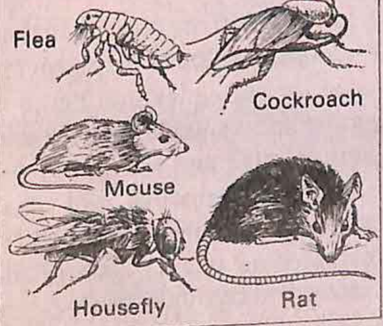


BACTERIA

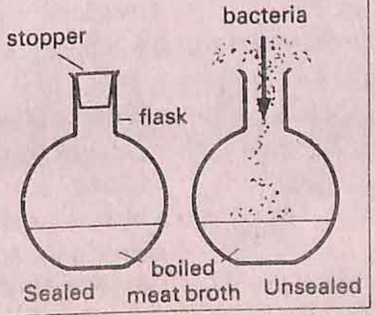


Very tiny living plants

SOME VECTORS

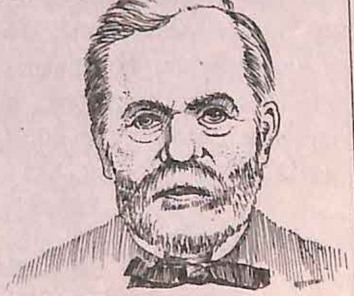


GROWING BACTERIA



LOUIS PASTEUR

1822-1895



36 Trees

Deciduous trees

Trees have woody stems, or trunks, that are covered in bark. They are much larger in size than herbaceous plants.

The leaves of deciduous trees fall in autumn. The wood of deciduous trees is hard. It is used, therefore, for making tools and good quality furniture. The flowers of many deciduous trees are grouped in catkins. The seeds of deciduous trees are contained in fruits.

Coniferous trees

Coniferous trees, or conifers, are evergreens; all their leaves do not fall in autumn. The cypress and larch are exceptions. They are conifers which have the habits of deciduous trees. The wood of conifers is soft and easily worked. It is used, therefore, for building work. Telegraph poles are made of timber from conifers. Conifers have thin needle-shaped leaves and catkin-like flowers. The seeds of conifers are contained in *cones,* which are made up of woody scales.

Some common trees

Useful clues to the identity of a tree are given by its flowers, fruits, bark, leaves and outline shape. Oak trees are easily recognised by their acorns and their irregularly-shaped leaves. Sycamore fruits, which twist and turn like helicopters, are familiar to everyone. The birch is recognised by the silver colour of its bark. Conifers are tall and triangular in shape. Tall poplar trees are easily recognised. The red berries and prickly leaves of holly are very distinctive. Here are some trees which you should be able to recognise:

Oak; poplar; cedar; lime; larch; birch; walnut; holly; spruce; elm; hornbeam; willow; sycamore; horse-chestnut; hawthorn; hazel; beech; ash; alder; yew; plane; elder; Scots pine; Douglas fir; almond; box.

Collecting leaves

Make a collection of leaves. One of the illustrations shows you how to do this.

Bark rubbings

Hold a sheet of thin white paper against a tree trunk. Rub the exposed side of the paper with cobbler's wax. The wax impression shows the markings on the trunk. Repeat this with different trees. Label the rubbings.

Leaf impressions

Press a leaf on a flat piece of plasticine to make a mould. Remove the leaf. Make a mixture of plaster of Paris and water which has the consistency of thick cream. Pour this plaster on to the mould and allow it to stand for twenty minutes. Remove the plasticine. Paint the leaf impression on the plaster with green water-colour. Label your leaf impressions. These plaster casts, which are permanent and accurate, could be kept as part of a museum.

Wood samples

Saw small lengths off the branches of common trees, *but not without permission.* Attach paper labels to them and hang them up with string.

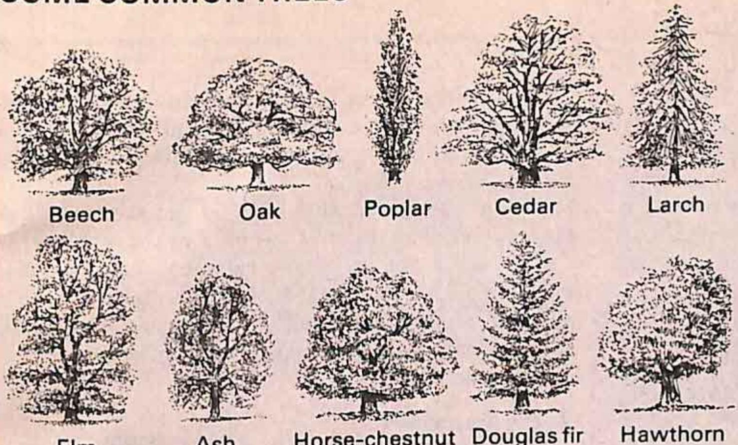
Tree recognition charts

If time allows, each member of your class could be responsible for making a tree recognition chart in the manner shown in the illustration.

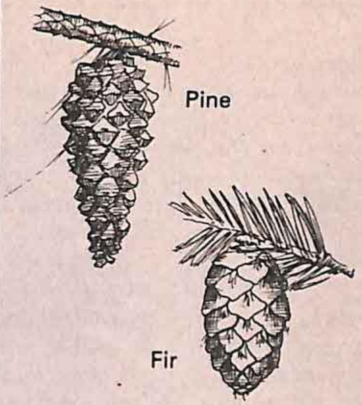
The uses of trees

Trees have many uses. Oak trees provide timber for building and making furniture: they provide *tannin* which is used for curing leather. Beech is used for making tools and valuable oils. Fir and pine trees provide turpentine and soft timber for building. Box trees provide a smooth hard wood which is used for engraving and turnery work. Hazel nuts are eaten. Find out the uses of the trees listed in the section on common trees.

SOME COMMON TREES

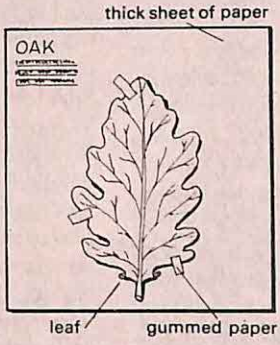


CONES

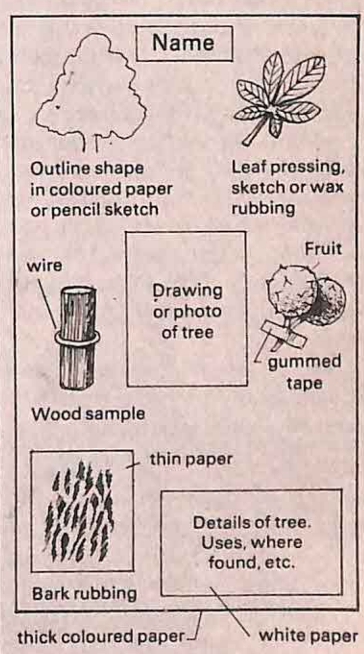


COLLECTING LEAVES

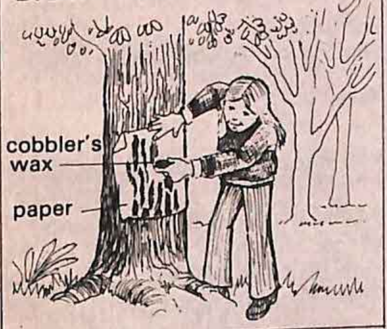
1. Use leaves which are dry and in a good condition.
2. Place each leaf between two sheets of thick plain paper.
3. Press the leaves by placing the sheets beneath heavy weights, such as piles of books.
4. After several weeks, when the leaves have been pressed, fix the leaves in place with small pieces of gummed paper.
5. Write labels on the sheets, with the names and the details of the plants from which the leaves came.
6. Cover the sheets with cellophane.
7. Arrange the sheets in alphabetical order for easy reference.



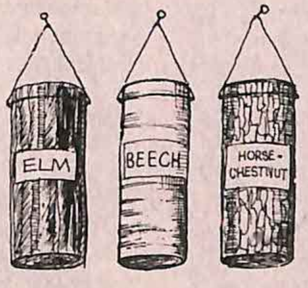
TREE RECOGNITION CHART


Name
Outline shape in coloured paper or pencil sketch
Leaf pressing, sketch or wax rubbing
Fruit
wire
Drawing or photo of tree
gummed tape
Wood sample
thin paper
Details of tree. Uses, where found, etc.
Bark rubbing
thick coloured paper
white paper

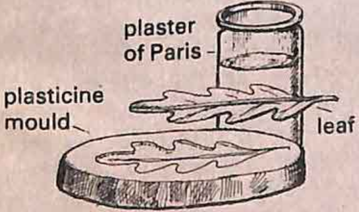
BARK RUBBINGS



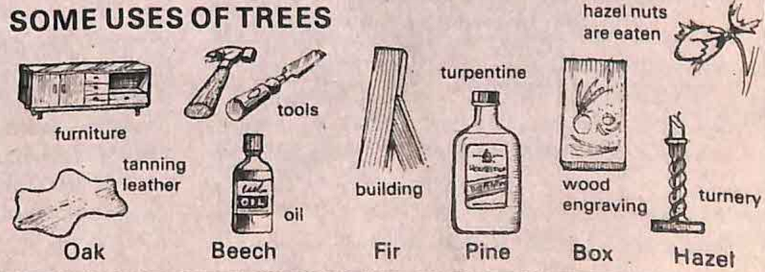
WOOD SAMPLES



LEAF IMPRESSIONS



SOME USES OF TREES



Exercises

1 Science

1. Keep a science scrap-book. A scrap-book can be made quite cheaply from brown paper, kitchen paper, or even sheets of newspaper, folded and held together with metal staples or stitches of strong thread. Make an attractive cover. This book can be made at home or as part of your Science Club activities. The following material is suitable for inclusion:

Your own photographs; cuttings of articles, quotations and verses; photographs and pictures from magazines and newspapers; small samples and specimens; your own written articles, notes, graphs, charts and sketches; foreign stamps with pictures of plants and animals; your notes about television and radio broadcasts.

2. Make a list of some of the things science has given you which would not have been available two hundred years ago. Pay particular attention to transport and communications, health services, entertainments, home comforts, heating and lighting, agriculture and industry.

3. Answer these questions (with full sentences):

(a) How might you have travelled three hundred years ago? (b) Who provided entertainment during the Middle Ages? (c) What are the three methods of science? (d) What was used as a fuel in the Middle Ages? (e) What is a detergent? (f) Where are anaesthetics used? (g) What was used for moving heavy loads before the invention of the wheel? (h) What was the first kind of axe used by man? (i) What are fertilizers? (j) What is technology?

4. Make a list of *ten* simple labour-saving devices in your own home.

5. Make a list of *ten* early inventions. Use an encyclopaedia.

6. Copy and complete this table:

The Sciences

Science	*Study of*
Botany	Plants
	Sun, moon and stars
	Human mind and behaviour
	Heat, light, sound and electricity
	Sizes in number, weight, time and space
Geology	
Zoology	
	What things are made of
Meteorology	
Biology	

7. Obtain photographs, pictures and cuttings dealing with scientific matters from newspapers and magazines. Pin these up on a notice-board with some suitable title, such as *Science News and Notes*.

8. Visit a museum. Make brief notes and sketches about some of the things you see. Later on, if you have time, write a short article for the school magazine. Pay particular attention to the following: tools and weapons; pictures showing surgical instruments, transport, building, dress, great scientists, etc.; working models; machines and instruments.

2 The Atmosphere

1. Complete these sentences. (Copy the sentences and fill in the blank spaces with suitable words.)

(a) Fluttering flags, leaves and trees moved by winds, and the damage caused by gales are proof that———————is real. (b) The Earth is surrounded by a layer of air about 300 km in depth called the ————————. (c) Miners entombed by a fall of rock often die from lack of pure ————————. (d) Drowsiness in a badly ventilated room is the result of breathing ———————— air. (e) The greatest height reached by unmanned balloons is about ———————— km. (f) An athlete running needs more ———————— than a person at rest. (g) People at a great height breathe ———————— because there is less air there. (h) A person at rest breathes in and out about 16 times per ————————. (i) Active animals breathe————————.

2. Write sentences to show the meanings of these words. (The words must be contained in the sentences. Write a separate sentence for each word.)

Ventilation; inspiration; expiration; atmosphere; inverted; stratosphere.

3 Breathing

1. Make a labelled drawing of the human respiratory system.

2. Write sentences to show the meanings of these words:

Fuel; inflate; deflate; contract; expand; mammal.

3. Write down the names of *two* animals which breathe through (a) lungs, (b) gills, (c) breathing tubes, (d) skins.

4. Complete these sentences:

(a) The tiny breathing tubes of insects are called ————————. (b) Both mammals and reptiles breathe through ————————. (c) Seeds will not germinate without ————————. (d) The breathing holes on the leaves of plants are called ————————. (e) The tadpoles of frogs and toads breathe through ———————— in the early stages of their lives. (f)————————is changed by breathing. (g) A candle burns for a time in ordinary air but does not burn for long in————————air.

Exercises

4 Oxygen

1. Answer these questions:

(a) What useful purpose is served by the nitrogen in the atmosphere? (b) Does oxygen burn? (c) Do things burn in nitrogen? (d) What happens when a glowing splint is lowered into a test-tube containing oxygen? (e) Will rusting of iron occur if oxygen and water are not present? (f) What happens when hydrogen peroxide solution is brought into contact with manganese dioxide? (g) Is oxygen necessary for burning as well as breathing? (h) How can one put out small fires?

5 Carbon Dioxide

1. Complete these sentences:

(a) Expired ________ from your lungs contains carbon dioxide gas. (b) ________ is used by the burning material in a candle to form carbon dioxide gas. (c) In all breathing organs ________ is taken in and carbon dioxide is given out. (d) Plants breathe in ________ and breathe out carbon dioxide. (e) Carbon dioxide is heavier than ________. (f) A lighted taper placed in a gas-jar containing carbon dioxide is ________. (g) Fizzy drinks contain carbon dioxide ________. (h) Caustic soda solution ________ carbon dioxide gas.

2. Write brief explanations of these statements:

(a) The lighted taper test for carbon dioxide could be dangerous. (b) Carbon dioxide is formed during breathing and burning.

3. Write down *three* everyday uses of carbon dioxide.

6 Air

1. Answer these questions:

(a) What fraction of air is nitrogen? (b) What fraction of air is oxygen? (c) Which of the inert gases is used for filling balloons? (d) Which of the inert gases is used for filling electric lamp bulbs? (e) Do the inert gases burn? (f) What is the colour of steam? (g) What happens to steam when it meets a cold surface? (h) What happens to blue cobalt chloride paper when it is placed in a damp atmosphere? (i) Why is hydrogen gas dangerous? (j) Who made oxygen in 1774 by heating the red oxide of mercury? (k) How is commercially-made liquid oxygen stored? (l) How is oxygen made commercially?

2. Write down *three* everyday uses of oxygen.

3. Write sentences to show the meanings of these words: Filament; inert; evaporate; neon; vapour; cloud; steam; hygroscopic.

4. Write a few sentences to explain why a housewife prefers a dry day, rather than a wet day, for doing her washing.

7 Aquaria

1. Complete these sentences:

(a) A crayfish breathes by means of ________. (b) Fish breathe the air dissolved in ________. (c) Fish will not ________ in water which has been boiled for it contains no air. (d) Water plants help to keep the water in an aquarium tank supplied with ________. (e) Water enters the ________ of a fish and leaves from behind the gill-covers. (f) An air-pump is sometimes used to ________ aquarium water. (g) A water-boatman breathes through ________, or breathing tubes. (h) The gills of a crayfish are protected by a hard shell called a ________. (i) Sunlight encourages the growth of a green scum of ________ on the bottom and sides of an aquarium tank. (j) A few ________ help to keep the water in a tank clean.

2. Use tracing paper to make copies of some of the animals shown in this chapter.

8 Water Everywhere

1. Answer these questions:

(a) What things, other than seas, oceans, lakes and rivers, contain water? (b) What fraction of living tissue consists of water? (c) Why do copper sulphate crystals lose weight when they are strongly heated? (d) Why does a cabbage lose weight when it is allowed to stand for several days? (e) Will seeds grow without water? (f) Why is it healthy to perspire freely in a hot climate? (g) What is "white coal"?

2. Write down *six* everyday uses of water.

3. A fresh cabbage weighs 2 kg. Its weight, after standing for several days, is found to be 1 kg. What is its percentage loss in weight?

9 The Water Cycle

1. Make labelled drawings to explain (a) the water cycle, (b) the rain cycle.

2. Write sentences to show the meanings of these words: Mist; fog; porous; condense.

3. Write brief explanations of these statements:

(a) Petrol on your hand feels cold. (b) In hot countries water is kept cool in earthenware pots. (c) Clouds and rain are sometimes formed when warm air meets cold air. (d) Wet streets dry quicker on warm days than on cold days.

10 Water in Plants

1. Answer these questions:

(a) What is the name of the process by which plants give out water through their leaves? (b) What instrument is used for measuring rainfall? (c) Why is a rain-gauge fitted with a funnel? (d) How is soil water replenished? (e) Why is oil sometimes put into rain-gauges?

2. Write a few sentences to explain why the water collected in a rain-gauge is usually poured into a measuring jar with a narrow diameter.

Exercises

11 Water Supplies

1. What are the probable water sources of these people?
(a) Australian sheep farmer. (b) Arab. (c) Eskimo. (d) British town-dweller. (e) British farmer. (f) British villager living where there is no piped water supply.

2. Make simple labelled sectional drawings of (a) a well, (b) a spring, (c) an artesian well.

3. Complete these sentences:
(a) The piped water supplied to towns and cities is stored in __________. (b) There are many __________ wells in Australia. (c) The Romans used pipes made of earthenware, stone and __________. (d) Well-water contains impurities such as dirt and __________. (e) Romans heated their baths by dropping __________ stones into the water. (f) Arabs depend upon isolated __________ for their water supplies. (g) An aqueduct is a bridge used for carrying __________.

4. Try to obtain pictures of some of the following. Paste these, with suitable labels, into your notebook.
Roman villa; oasis; well; spring; artesian well.

5. Write brief explanations of these statements:
(a) Springs dry up during a severe drought. (b) Eskimoes melt ice and snow to provide water for drinking and cooking. (c) The drinking of unboiled well-water could lead to serious illnesses.

12 Your Water Supply

1. Complete these sentences:
(a) Water finds its own __________. (b) The air bubble is centrally placed in a spirit-level when it is lying on a __________ surface. (c) The __________ part of a dam has to withstand great pressures of water. (d) Water pressure increases with __________. (e) __________ does not "stick" to the sides of the tube in a spirit-level. (f) __________ are sometimes used for moving water over hills.

2. Make simple labelled sectional drawings of (a) a water-tower, (b) a river with a dam.

3. Show the positions of the following by drawing black crosses with printed labels on a map of your district:
Reservoirs; fire-stations; pumping-stations; water-towers; softening-stations; nearest fire-hydrant; wells; artesian wells, if any; lakes; ponds.
Note: Artesian wells occur in the London area in the natural basin between the Chilterns and the Weald.

4. Visit local fire-stations, water-works and reservoirs. Make notes and sketches about some of the things you see.

5. Estimate the amount of water used in one week by each member of your family for washing, cleaning, cooking and drinking. Determine the amount of water used by the whole family in one week.

The information required for this question can be arranged in a table as follows:

Water Used by my Family in One Week

Person	*Drinking*	*Cooking*	*Washing*	*Cleaning*	*Total*
Myself					
Father					
Mother					
Brother John					
Sister Susan					

Water used in one week =

13 A House Water System

1. Consider a house water system and then state the purposes of the following:
(a) Cistern. (b) Service pipe. (c) Fire-hydrant. (d) Street stopcock. (e) House stop tap. (f) Street main pipe. (g) Hydrant notice.

2. Make a labelled sectional drawing of a hot-water system.

3. Write a few sentences to explain how you would (a) remove an obstruction in a blocked sink, (b) lag a water pipe.

4. Write brief explanations of these statements:
(a) The house stop tap is very useful. (b) Hot water rises and enters the hot-water cylinder.

14 Water Fittings

1. Make labelled sectional drawings of (a) a lavatory trap, (b) a sink trap, (c) a lavatory cistern.

2. Write a few sentences to explain how you would (a) re-washer a tap, (b) prevent leaking from a tap gland.

3. Write *one* sentence about each of these terms:
Bib tap; stop tap; jumper; spindle; ball-valve; siphon bell; flush pipe; water trap.

4. Write a full explanation, with drawings, of how the water flowing from the inlet pipe of a lavatory cistern is controlled by a ball-valve.

15 Keeping Warm

1. Write down the methods used by these animals for keeping warm in winter:
(a) Cat. (b) Horse. (c) Rabbit. (d) Sheep. (e) Squirrel. (f) Bat. (g) Robin. (h) Swallow. (i) Frog. (j) Badger. (k) Stickleback. (l) Hedgehog. (m) Cuckoo. (n) Man. (o) Starling. (p) Bee. (q) Goose. (r) Tortoise.

Exercises

2. Write down *ten* materials which are good heat insulators.

3. Write sentences to show the meanings of these words: Exposure; sett; byre; migrate; hibernate; drey; insulator.

4. Try to obtain pictures of some of the following. Paste these, with suitable labels, into your notebook.
Animals which hibernate; birds which migrate; sheep; rabbit; hare; dog; horse; badger's sett; squirrel's drey; byre; stable; poultry hut.

16 Heat Insulators

1. Answer these questions:
(a) Which is the better heat conductor—wood or copper? (b) Which are the better heat conductors—metals or non-metals? (c) Why are granules of vermiculite laid between the rafters in the roofs of some houses? (d) Why are potato clamps lined with straw? (e) Why do pokers and soldering irons have wooden handles? (f) Which is the warmer garage in summer—one made of wood or one made of aluminium? (g) Why is snow sometimes called "nature's blanket"? (h) Why are the roofs of houses insulated? (i) Why are feathers and hair good heat insulators? (j) Why do birds fluff out their feathers in cold weather?

2. Write down *six* everyday uses of heat insulators.

3. Try to obtain pictures of some of the following. Paste these into your notebook.
Soldering iron; carpet; rug; eiderdown; blanket; table mat; tea cosy; Eskimo's igloo.

4. Make a labelled sectional drawing of a potato clamp.

17 Heat Energy

1. Answer these questions:
(a) What is electricity used for? (b) What is the Law of Conservation of Energy? (c) What are the uses of heat in the home? (d) What are the uses of heat in industry? (e) Why does the blade of a saw become warm after several minutes of use?

2. Write down some common examples of heat energy being made (a) chemically, (b) electrically, (c) mechanically.

3. Try to obtain pictures of some of the following. Paste them into your notebook.
Electric iron; cooking utensils; locomotive; electricity power-station; foundry; electric fire; motor car.

18 The Expansion of Solids

1. Complete these sentences:
(a) The expansion of metals is so———that it is not always noticeable. (b) The "creeping" of lead on a roof is due to ———. (c) Brass expands more than ———. (d) A compound bar made of strips of brass and steel riveted together bends when heated because the brass expands more than the ———. (e) Materials expand when they are heated and ——— when they are cooled.

2. Write down *six* examples of where allowances are made for expansion due to heat.

3. Make drawings of (a) a looped steam pipe, (b) an adjustable pendulum.

4. Write brief explanations of these statements:
(a) It is foolish to pour hot water into thick glass tumblers.
(b) Heat expansion helps in the formation of deserts.

19 The Expansion of Liquids and Gases

1. Complete these sentences:
(a) Liquids expand more than ———. (b) ———expand more than liquids and solids. (c) It is unwise to stand a stoppered bottle in front of a fire because the air and gases contained in it———and may break the bottle with explosive force. (d) Paraffin expands more than ———. (e) Explosions are caused by the rapid——— of gases and vapours.

2. Make a labelled sectional drawing of the cylinder of a petrol engine.

20 Using Expansion

1. Write down *six* useful applications of heat expansion.

2. Complete these sentences:
(a) Hot air balloons were first used in Europe by two Frenchmen, Joseph and Etienne———. (b) A steam turbine was mentioned by ——— of Alexandria about 150 B.C. (c) Liquids which expand rapidly, such as alcohol and ———, are used in thermometers. (d) Expansion is used for loosening tight bottle stoppers and rusty———.

21 Thermometers

1. Write a brief and simple explanation of the difference between heat and temperature.

2. Complete these sentences:
(a) The senses are unreliable as indicators of———. (b) "Thermo" means ——— and "meter" means "measure". (c) An air thermometer was used by ——— in 1593. (d) Metal thermometers for measuring high temperatures are called ———. (e) The glass bulb of a classroom thermometer is protected by a metal———.

Exercises

22 Measuring Temperature

1. Draw (a) a laboratory thermometer, (b) a classroom thermometer, (c) a clinical thermometer.

2. Answer these questions:

(a) Which temperature scale is shown on a thermometer? (b) What is the boiling-point of water on the Celsius scale? (c) What is the freezing-point of water on the Celsius scale? (d) What is the normal temperature of the human body? (e) What instrument is used by doctors and nurses for measuring temperature? (f) What are the fixed points? (g) What is the purpose of the constriction in a clinical thermometer?

23 Cooling

Complete these sentences:

(a) Below 4°C, water ———— on cooling. (b) Burst water pipes are caused by the ———— of ice. (c) Icebergs float because ———— is lighter in weight than water. (d) Ponds do not freeze up because the warmer, heavier water sinks and the cooler, ———— water floats. (e) Above 4°C, water ———— when it is heated. (f) The normal body temperature of a horse is ————. (g) Rapid cooling is prevented by using ————. (h) A freezing mixture is made from common salt and crushed ————. (i) In hot weather perspiration forms on skin pores; this ———— and takes heat from the body in order to do so. (j) It is unwise to sit about after taking vigorous exercise because rapid cooling causes ————.

24 Burning

1. Complete these sentences:

(a) ———— and breathing use oxygen. (b) Magnesium burns in carbon dioxide and black clouds of ———— particles are formed. (c) Burning a candle results in the formation of carbon dioxide and ————. (d) Soot is unburnt ————. (e) Incomplete burning is caused by lack of ————. (f) Oils and ———— contain hydrogen and carbon. (g) Yellow phosphorus is stored in sealed jars containing ———— so that spontaneous burning does not occur. (h) Some materials, like petrol, ———— and phosphorus, burn very easily and rapidly. (i) ———— + oxygen = carbon dioxide.

2. Write *two* sentences about each of these topics:

(a) Incomplete burning, (b) carbon monoxide, (c) spontaneous combustion.

3. Make a list of *ten* common materials, such as soap, candles, lard, etc., which contain hydrogen and carbon.

25 Fires and Flames

1. Make labelled sectional drawings of: (a) a stove, (b) a grate, (c) a candle flame.

2. Complete these sentences:

(a) The luminous part of a flame is made of white-hot particles of ————. (b) Chimneys create draughts of ———— which ensure complete burning. (c) Stoves and grates burn slowly when their ———— are pushed in. (d) A locomotive blast-pipe supplies ———— under pressure, which creates a draught. (e) The ———— created by a locomotive blast-pipe draws air through the fire, which burns rapidly. (f) Factory ———— carry away unpleasant smoke and fumes. (g) ———— are burning gases and vapours. (h) A stove can be kept burning slowly all night by closing the ————. (i) The inner region of a candle flame consists of ———— vapour.

26 Fuels

1. Write down the names of *eight* common fuels.

2. Write *one* sentence about each of the following:

Coal; coke; fossils; peat; lignite; paraffin; petrol; methylated spirit.

3. Write down *one* use of each of these materials:

Coke; paraffin; petrol; turpentine; alcohol; methylated spirit; peat.

4. Answer these questions:

(a) Which chemical material is contained in all living things? (b) Who illuminated his office with coal-gas in 1792? (c) What is the colour of lignite? (d) What is the colour of the flame of burning methylated spirit? (e) In which country is peat used in large quantities? (f) Why do oils burn with luminous flames?

5. Write an essay with the title *Coal*. Expand these paragraph notes:

Formation of coal. Vast forests before the Age of Giant Reptiles. Modern ferns and horsetails. Floods and subsidences. Mud, sand and rocks, Coal seams. Outcrop coal.

Coal is wood. Fossils of plants and animals. Chemicals in coal. Lignite. Peat.

Uses of coal. Domestic fires. Steam-raising. Power-stations.

Coal-gas. Murdoch, 1792. Making coal-gas.

6. Write a few sentences about *oil* and *natural gas*.

Exercises

27 The Bunsen Burner

1. Answer these questions:
(a) How is the size of a bunsen burner flame altered? (b) Who designed the gas burner you use in the laboratory? (c) Under what conditions is a bunsen burner flame almost colourless? (d) How is the hotness of a bunsen burner flame controlled? (e) When does striking back occur? (f) How is striking back cured?

2. Make a labelled sectional drawing of a non-luminous bunsen burner flame.

3. Make a labelled drawing to show the parts of a bunsen burner.

4. Write out the list of precautions you would take when using a bunsen burner.

28 Carbon

1. Write down the names of *four* common forms of carbon.

2. Write *one* sentence about each of the following:
Allotropes; graphite; diamonds; charcoal; soot; printer's ink.

3. Write down *one* use of each of these materials:
Graphite; diamond; wood charcoal; animal charcoal; soot.

4. Complete these sentences:
(a) Coal and ______ contain carbon. (b) ______ is used as a smokeless fuel. (c) Graphite is ______ and soft. (d) Pencils are made from ______ and wood. (e) Diamonds are used in ______ and cutting tools. (f) A method for making ______ artificially was invented by Moissan. (g) Wood ______ is used for absorbing gases. (h) Sugar charcoal is a pure form of ______. (i) ______ charcoal is used for decolourizing sugar syrups. (j) Artist's charcoal is made from ______.

29 The Plant Kingdom

1. Make a list of the main activities of living things.

2. Complete these sentences:
(a) Plants are ______ in colour because they contain chlorophyll. (b) All living things are either plants or ______. (c) Animals move about but ______ live and grow in the same place. (d) Plants feed on ______ salts in the soil and carbon dioxide in the atmosphere. (e) Animals feed on plants and other ______. (f) Animals are complicated but plants are ______. (g) Both plants and animals breathe ______. (h) Plants are not so sensitive to ______ as animals. (i) A plant grows towards ______. (j) An animal moves away from ______. (k) Animals grow from eggs and plants grow from ______

3. Write down the names of *three* flowering plants which are (a) coniferous, (b) deciduous, (c) herbaceous.

4. Write down the names of the flowerless plant families.

5. Write down the names of the plant families with these characteristics:
(a) Woody stems. Shed leaves in autumn. (b) Woody stems. Retain their leaves in winter. (c) Several woody stems arising from the ground. (d) Non-woody stems. (e) Do not contain chlorophyll and feed on decaying vegetation. (f) Very tiny and without chlorophyll. Some cause diseases. (g) Flowerless. Grew in the primeval forests from which the coal measures were formed. (h) Grow on the bottom and sides of an aquarium tank. Green and tiny.

6. Show the variety to be found in the plant kingdom by pasting a few pictures of various plants into your notebook. Obtain suitable pictures from seedsmen's catalogues. Perhaps your father has some old catalogues he will give you.

7. Write down the names of the plants and animals which give the following. Use an encyclopaedia.
Beef; mutton; pork; venison; vinegar; peat; turpentine; deal; mast; hay; straw; port wine; cocoa; paper; honey; linen; silk; vanilla; carmine; tobacco; pearls; opium; digitalis; latex; linseed oil; olive oil; castor oil; buttons; velvet; flannel; bath sponges; ropes; cork.

8. Make a display of some common commodities which are made from plants and animals, such as cotton, silk, wool, sponges, coke, vinegar, string, corks, tobacco, buttons, etc. Print the words *Nature Works for Man* in large letters on a piece of white cardboard. Stand the card near to the display.

9. Write sentences to show the meanings of these words:
Chlorophyll; fungi; herbaceous; deciduous; algae; spice; fodder; evergreen.

10. Make a nature calendar. Staple or sew together 12 large sheets of white paper. Make an attractive cover to hold the sheets of paper. Head each sheet with the name of the month. Make drawings and notes about the things you see—and hear, such as bird sounds—when you are out of doors. This calendar can be made at home or as part of your Science Club activities.

Include cuttings from magazines, newspapers, etc., photographs, specimens, your own sketches, verses and quotations. Pay particular attention to observations of plants, animals, stars, the weather, rocks, soils and the activities of the gardener and the farmer.

Exercises

30 Flowering Plants

1. Complete these sentences:

(a) Stems hold plants erect and transport food and ———— to leaves and flowers. (b) Leaves trap sunlight, breathe air and transpire ————. (c) Roots hold plants firmly in the soil and take in ———— and water. (d) Some roots are swollen and contain ————. (e) Flowers contain the male and ———— parts of a plant. (f) Clematis plants have twisted ————. (g) A ———— leaf is divided into several small leaflets. (h) An oak leaf has network veins and a plantain leaf has ———— veins. (i) The blade of a leaf is called the ————. (j) A leaf-stalk is called the ————. (k) Shepherd's purse has a ———— root. (l) Onions have ———— roots. (m) Carrot and parsnip roots contain ———— for next year's growth. (n) Sweet peas have ———— which enable them to attach themselves to the stems of other plants. (o) The ———— has thorns.

2. Write sentences to show the meanings of these words: Organ; lamina; petiole; parallel; tendril; compound; fibrous; network.

3. Visit a park. Make notes and sketches and, if possible, take photographs of some of the plants you see. Some of these sketches and photographs could be included in the school magazine. Pay particular attention to the following. Tremendous variety in shapes, sizes and colours of plants; leaves—shapes and veins; stems—twisting, tendrils, thorns, woody, etc.; flowers—size, shape, colour, number of petals, etc.

31 Plant Families

1. Complete these sentences:

(a) Bulbous buttercups, wood anemones and ———— belong to the buttercup family. (b) Foxgloves, deadly nightshade, henbane and monkshood are ———— plants. (c) Toadstools are ———— fungi. (d) Cereals are cultivated ————. (e) ———— and sugar cane are members of the grass family.

2. Make a list of some of the common poisonous plants growing in Britain.

3. Write down the names of *two* foods which are (a) fruits, (b) seeds, (c) leaves, (d) stems, (e) flowers, (f) roots.

4. Write down the names of *six* cereal plants.

5. Use tracing paper to make copies of some of the plants shown on page 69.

32 New Plants

1. These phrases describe the stages in the life-cycle of a flowering plant. Write them down in a proper natural order.

Seed; young plant; fruit; germinating seed; flower withers; pollination; plant dies; mature plant; seed dispersal.

2. Write down the names of *three* plants which are (a) annuals, (b) biennials, (c) perennials.

3. Answer these questions:

(a) Why do plants produce many seeds? (b) What useful purpose is served by decaying plants? (c) How are trees protected against the severe cold of winter? (d) Why do carrots and parsnips have swollen roots? (e) How is the public protected against the sale of bad seeds? (f) How are seeds killed?

4. Write down the names of *twenty* plants which grow from seeds.

33 Growing Seeds

1. Complete these sentences:

(a) Seeds germinate if they are given oxygen, warmth and ————. (b) Seeds ———— best in darkness. (c) The part of a bean which is joined to the pod is called the ————. (d) The seed coat of a bean is called the ————. (e) The young shoot which emerges from a bean is called the ————. (f) Cotyledons are the ———— leaves. (g) The side roots on a root are called ———— roots. (h) The young root which emerges from a bean is called the ————. (i) A broad bean has ———— cotyledons. (j) A bean takes up water through the ————.

2. Write sentences to show the meanings of these words: Micropyle; hilum; testa; radicle; plumule; lateral; embryo.

3. (a) 50 seeds are placed in soil in a box and regularly watered. 46 seeds germinate and grow. What percentage of the seeds have germinated? (b) A gardener sows 2000 seeds, but only 1800 seeds germinate. What percentage of the seeds have germinated?

34 Flowers And Seeds

1. Write a few sentences to describe the three ways in which pollen is carried from one flower to another.

2. Write brief explanations, with simple drawings, of (a) cross-pollination, (b) self-pollination. Give one example in each case of a plant using that method of pollination.

3. Make a labelled sectional drawing to explain the process of fertilization in a flowering plant.

Exercises

4. Copy and complete this table:

The Parts of a Flower

Part	*Work*
Stigma	Sticky. Receives and holds pollen.
	Made up of coloured petals. Attracts insects.
	Made of sepals. Protects bud.
Stamen	
Pistil	
	Makes and releases pollen grains.
Filament	
Style	
	Contains ovules and seeds.
Ovule	
	A fertilized ovule. Grows into new plant.

5. Complete these sentences:
(a) After ________ ovary walls grow thicker. (b) A pollen ________ grows down a style and unites with an ovule. (c) In an apple the ________, which is the top of the flower stem. becomes very swollen. (d) A ripe apple possesses the withered remains of the ________. (e) The swollen ________ of an apple contains white pulp.

6. Write a few sentences to explain how bees do much useful work in the pollinating of flowers.

35 Flowerless Plants

1. Complete these sentences:
(a) Mushrooms are not green because they do not contain ________. (b) Ferns and horsetails have roots, stems and leaves but no ________. (c) Seaweeds are ________. (d) Fungi and ________ grow quickly. (e) Ferns, fungi and moulds reproduce themselves by means of ________. (f) The white threads in mushroom spawn are called ________.

2. Write down the names of three common (a) ferns, (b) fungi.

3. Make three simple labelled drawings to show how bacteria are classified by their shapes.

4. Write sentences to show the meanings of these words:
Bacilli; putrefaction; pasteurization; sterilizes; antiseptic; vectors.

36 Trees

1. Complete these sentences:
(a) ________ have woody stems. (b) Trees are ________ plants because they go on growing year after year. (c) Wood from conifers is soft and that from deciduous trees is ________. (d) Conifers are usually ________, that is, they retain their leaves during winter. (e) Deciduous trees have broad leaves but ________ have thin needle-shaped leaves. (f) The seeds of conifers are contained in ________. (g) The fruit of an oak tree is called an ________. (h) The ________ is easily recognised because its fruits are winged and in pairs. (i) The ash is easily recognised by its compound leaves with ________ leaflets. (j) The silver birch is so called because of the silver colour of its ________.

2. Write down the names of the evergreens contained among the following:
Sycamore; yew; oak; spruce; larch; Douglas fir; willow; cedar; Scots pine; elm; hawthorn; ash; mistletoe; beech; holly; almond.

3. Write down the names of *ten* deciduous trees.

4. Write down the uses of these trees. Use an encyclopaedia.
Oak; cedar; poplar; larch; birch; spruce; elm; willow; beech; ash; elder; Scots pine; box; hazel.

5. Write a few sentences to explain the meanings of the terms *seasoning, veneer* and *plywood.* Use an encyclopaedia.

6. Try to obtain pictures of some common British trees. Paste these into your notebook.

7. Use tracing paper to make copies of some of the trees shown on page 79.

8. Put a few prints of leaves of common trees in your notebook. Label them. Here are three ways of doing this.
(a) Place a leaf on a page in your notebook. Dab the edge of the leaf with a wet sponge which has been dipped in green powder paint. An outline shape of the leaf is made.
(b) Mix together black powder paint or soot and a few drops of olive oil. Put some of the mixture on a small pad of cotton wool. Dab the cotton wool pad on the underside of the leaf. Place the leaf, underside downwards, on a page in your notebook. Cover it with blotting paper. Press gently but firmly all over the leaf with your fingers. Remove the leaf and the blotting paper. You are left with a black leaf print showing veins. You could try this with green powder paint. (c) Place a leaf under a page in your notebook. Rub over the page with cobbler's wax.

Answers to Numerical Exercises

Chapter 8: 3. 50%.
Chapter 33: 3. (a) 92% (b) 90%.

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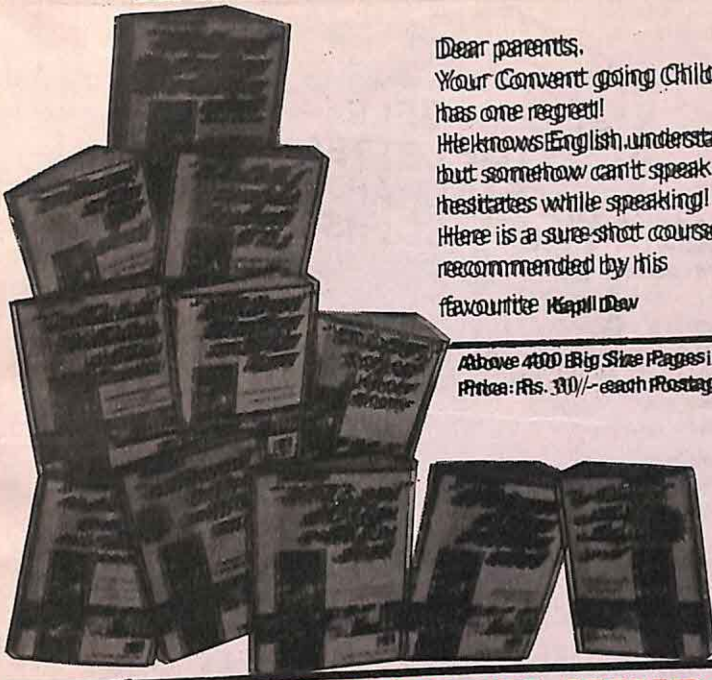

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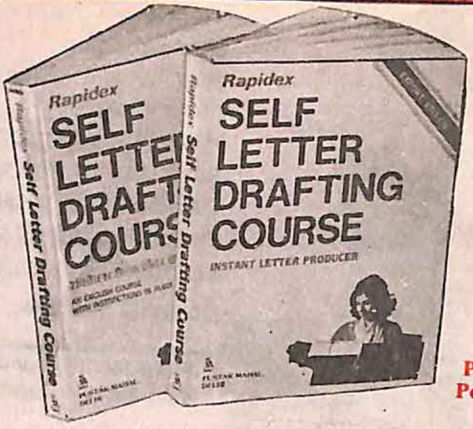

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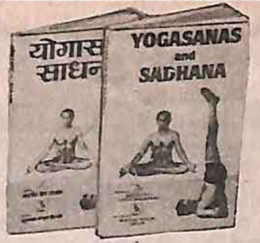

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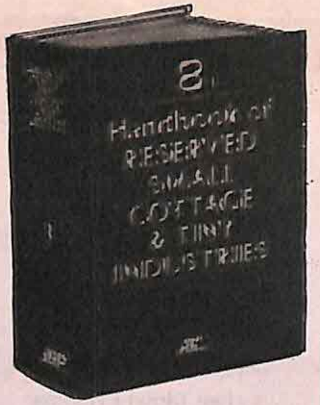

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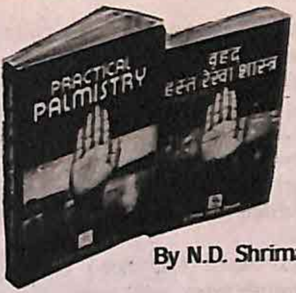

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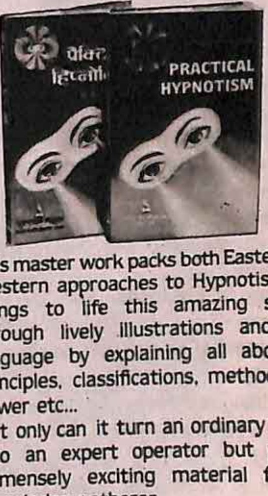

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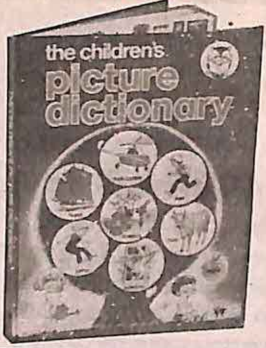

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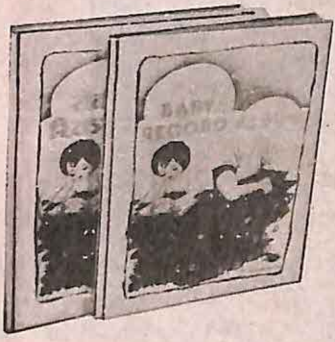

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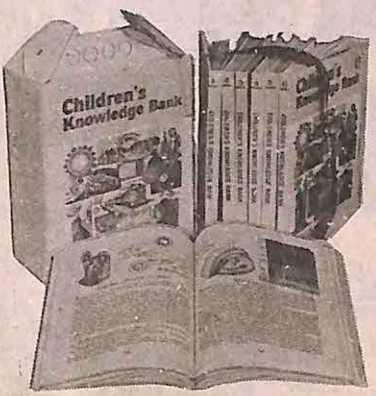

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